Teaching Topics in Human-Computer Interaction: A Practical Experience with a Focus on Experimental Research

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Abstract: This paper presents the results and lessons learned from the course Topics in Human-Computer Interaction (HCI) with a focus on experimental research. The course provides students with hands-on experience in planning, executing, and analyzing both primary studies (such as controlled experiments) and secondary studies (such as systematic mapping studies) to develop essential research skills in the HCI field. The course included five undergraduate students, one external student, two postgraduate assistants, and one professor. Based on the analyzed results, the main difficulties encountered by students in completing the practical works (PWs) were identified, along with an assessment of their completeness and progression in each PW.

1 INTRODUCTION

Learning about experimental research is fundamental for enabling future researchers and professionals to plan, execute, and analyze studies—key components of the scientific discovery process (Lazar et al., 2017). Kitchenham et al. (2022) classify these studies into two categories: primary and secondary. Primary studies involve empirical investigations that address specific research questions, while secondary studies synthesize and analyze evidence from multiple primary studies related to the same research question.

In this context, peer collaboration plays a crucial role in knowledge construction, as it allows students to share experiences, discuss challenges, and develop joint solutions (Kaptelinin and Nardi, 2009). The exchange of experiences among peers enriches the learning process, providing diverse perspectives and fostering an active and engaging educational environment. These practices are essential for preparing professionals to tackle the dynamic and complex challenges of the Human-Computer Interaction (HCI) field.

The primary objective of this work was to enable students to plan, execute, and analyze primary and secondary studies on Topics in HCI through practical assignments (PWs). The course was designed to develop students' critical thinking and analytical skills, both of which are fundamental to scientific research.

The course methodology involved four PWs, each focusing on a specific stage of the research process: (1) planning, executing, and presenting a Systematic Mapping Study (SMS), (2) planning, executing, and presenting a pilot study, (3) conducting a quantitative analysis of a primary study, and (4) conducting a qualitative analysis of a primary study. Each PW followed a structured sequence of steps with specific instructions and appropriate tools, and students were required to submit detailed reports upon completion. The assignments were completed both individually and in pairs.

To assess the experience, perceptions from students, assistants, and instructors were gathered through questionnaires and direct observations. Comparisons were also made between the PWs to identify and analyze the difficulties faced by students. The findings revealed that students struggled with understanding open and axial coding processes in qualitative analysis. Additionally, one student who worked in pairs found the experience to be more productive, emphasizing collaboration as a key factor in making the course more beneficial.

In summary, this work contributes to the fields of Informatics in Education and HCI by equipping students with essential research skills through a practical and collaborative approach. This is crucial for addressing real-world challenges in both academia and industry. Furthermore, the study reinforces the impor-

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tance of educational practices that promote collaboration and active learning through specialized tools and resources.

This paper is structured as follows: Section 2 presents related work, Section 3 describes the methodology, Section 4 details the results, Section 5 discusses the lessons learned, Section 6 provides further discussion, and Section 7 concludes with final considerations and future directions.

2 RELATED WORKS

This section presents examples of work that sought to facilitate the dissemination of content and promote learning experiences through different educational approaches, such as constructionism and the flipped classroom. These studies used interactive resources in face-to-face and online contexts intending to enrich the teaching and learning processes.

Perin et al. (2021) reported on the experience of using tools to support practical work in the Experimental HCI course. The course offered remotely was attended by undergraduate and postgraduate students in computing, and the inverted classroom dynamic was applied, in which students had access to the content before classes. A questionnaire was used to collect the students' perception of the tools, revealing that some difficulties could be overcome by reading support materials, further study of the tools, and contact with tutors, teachers, and assistants.

Givan and Savage (2019) presented a constructionist approach to working on learning experiences in virtual worlds. 24 students from a postgraduate course in Technology and Learning took part. Over four weeks, the students, most of whom had no previous experience in programming or using the *Second Life* platform, were grouped in pairs to take part in the activity. The experience was part of a course module that sought to integrate theory and practice. The activity included orientation phases, workshops, and an open assessment task, in which the students collaborated to create interactive installations in the virtual world. The installations were built on specific platforms, with spaces visible to each other to promote collaboration and socialization. At the end, the students presented their projects and reflections, highlighting both the learning of programming and the practical application of the concepts.

Martinelli and Zaina (2021) presented an approach based on a virtual flipped classroom for teaching HCI. The approach adds elements to both in-class and out-of-class moments. 33 undergraduate and ten postgraduate HCI students took part. Before the class, the students interacted with the HCI course material independently. Each week, the students focused on learning a unit. During class, the students took part in a synchronous meeting in an online room. After the lesson, the students were organized in different online rooms to carry out the practical exercise in small groups. The authors collected data twice. The first was after the 5th week of classes, using a questionnaire about their experience with the different formats of materials and activities in the classroom, using the Self-Assessment Manikin (SAM) (Lang, 1980). The second was through interviews with each group at the end of the course.

As in the reports by Martinelli and Zaina (2021) and Perin et al. (2021), the methodology used in this work also uses flipped classroom dynamics and support tools to promote active learning. However, it distinguishes itself by focusing on students' observations and perceptions throughout different PW, ranging from SMSs to primary studies and quantitative analyses. Unlike Givan and Savage's (2019) approach, which emphasizes virtual worlds, it integrated both virtual and traditional tools, combining face-to-face experiences and activities carried out outside the classroom. While Martinelli and Zaina (2021) explored the teaching of HCI, this methodology offered students greater flexibility in choosing tools and methods for the experimentation process. The combination of techniques and the careful assessment of each PW reinforce students' technical skills, preparing them to face real challenges in HCI research with a cohesive and systematic integration of theory and practice.

3 METHODOLOGY

3.1 Population and Sample

Regarding the population and sample, the perceptions of the students, assistants, and teachers about the Topics in the HCI course were analyzed. Five undergraduate students took the course from the Federal University of Paraná (UFPR) and one external student. The course also included two assistants who are PhD students in Computer Science from the Postgraduate Program in Informatics at UFPR (Figure1). The course began on February 28, 2024, and ended on August 9, 2024. The course has four hours per week and a workload of 60 hours. Topics in HCI aim to train students to be able to plan, execute, and analyze primary and secondary studies. Four PWs were carried out to achieve this objective. Each PW has its specifications and items to be carried out, so the assessment of the results delivered by the students is based on these specifications. The teacher advised the undergraduate students that they could work in pairs or individually as they wished.

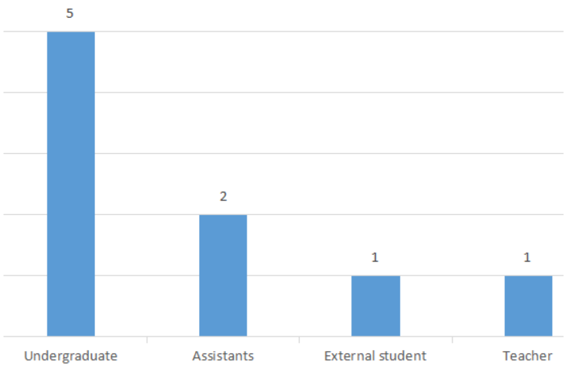

Figure 1: Population and sample.

3.2 Context

For the context, the four PWs are presented the Figure 2. PW1 consisted of planning, executing, and presenting an SMS. To carry out the SMS, the students were instructed to use the Porifera[1](Campos et al., 2022) tool (detailed in Subsection 3.3). For the planning stage, the teacher determined that the SMS protocol needed to meet a number of requirements: the context to identify and describe the need for the SMS, the objective of the SMS using the *Goal-Question-Metric* (GQM) (Kitchenham and Charters, 2007), define the main question and secondary questions, define the search *string*, choose the data sources, described the criteria adopted for selecting the data sources and the restrictions associated with the study, described the languages of the publications and justified the choice, defined the selection criteria (inclusion and exclusion) for the articles, and also defined the procedures adopted for selecting articles (1st and 2nd filter for selecting articles). For the researchers involved, in Porifera, the students added the teacher as a collaborator. For the pilot, they tested and retested the search *string* to refine it, always observing the results achieved in the digital libraries.

In order to carry out the SMS, some items had to be met, such as: altering and/or adding some selection criteria (inclusion and exclusion), defining a data extraction form, choosing one of the digital libraries defined in the protocol, and carrying out the search with the *string*, considering the first 30 articles returned by the digital library and exporting them in Bibtex format so that they could then be imported into Porifera. They carried out the 1st filter (reading the title and *abstract*) of the 30 articles in Porifera, then informed the teacher so that she could also carry out her evaluation and thus be able to generate consensus. They carried out the 2nd filter (complete reading) of the articles that had passed the 1st filter on Porifera and then informed the teacher so that she could carry out her assessment and thus generate a consensus. The information from the 1st and 2nd filters should be described in the report, as well as which articles passed or failed and by which inclusion and exclusion criteria. They interpreted the agreement and reliability indices (Kappa) in Porifera. Finally, they extracted data from at least one article that passed the 2nd filter and described it in the report. For the SMS presentation, the students had to develop slides and share them with their classmates.

PW2 consisted of planning, executing, and presenting a pilot study. The planning of the pilot study had to take into account some items, including: defining the objective of the study by the GQM (Kitchenham and Charters, 2007), formulating null and alternative hypotheses, selecting the dependent and/or independent variables and how they were collected and/or calculated, specifying the *design* of the study for *between group* or *within group* (Lazar et al., 2017), selecting the participants and the environment/place where the study should be carried out, defining the instruments and preparing them, as well as developing instructions and defining measurement procedures. They also assessed threats to validity.

To carry out the pilot study, the student invited at least two people to take part in their pilot study and carry it out. In the report, they described the personal characteristics and experiences of the pilot participants. They described how the preparation for the pilot was carried out, detailing the training and instructions to the participants. They also described how the experimental procedures were carried out in the pilot. For the presentation of the pilot study, the students had to develop slides and share them with their classmates.

PW3 consisted of a quantitative analysis of a primary study. In this PW, students had to identify a scientific article close to their research topic, which described a statistical analysis of a study, and which contained quantitative data to reproduce the statistical tests described in the article. They had to study the statistical tests of the study identified in the article and reproduce them using statistical software such as SPSS[2] or R[3] (detailed in Subsection 3.3). Finally, they developed a report containing the reproduction of these tests, describing each step carried out during

[1]https://porifera.app.br/

[2]https://www.ibm.com/br-pt/spss

[3]https://www.r-project.org/

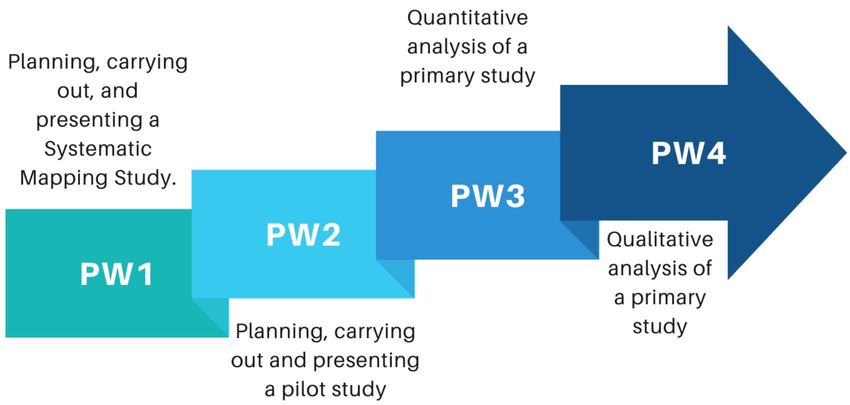

Figure 2: Context.

the tests in the statistical software and showing the results achieved.

PW4 consisted of developing and presenting a qualitative analysis of a study. Students could choose qualitative data obtained from a study related to the research. This could be qualitative data from their pilot study (PW2) if they had sufficient data or from a study reported in the literature that had access to raw data. If they didn't have any of these options, they could collect qualitative data through an interview, questionnaire, or observation on something related to the research topic. Next, the students had to analyze and code the qualitative data, identifying, naming, and recording recurring content in the complete data set (open coding). Afterward, they examined the result they had in hand and found more abstract categories into which the codes (classes of evidence) from the previous stage were grouped (axial coding). They also found significant relationships between the categories. The students were generally instructed to proceed as they felt most productive, but always maintaining systematicity and rigor in their analysis. Finally, the students wrote a report describing (a) the analysis process, (b) the results, and (c) the conclusions drawn from their work. Atlas.ti[4] was a suggested software for coding and categorizing the data (detailed in Subsection 3.3). The students developed slides and shared them with their classmates to present the qualitative analysis.

In addition to this work, the students were responsible for doing further reading and giving presentations on it. The readings included: the report by Kitchenham and Charters (2007) on systematic literature review, chapter 5 on Survey, chapter 7 on Case Study, chapter 5 on Statistical Analysis, and chapter 11 on Qualitative Analysis from the book by Lazar et al. (2017). To ensure that everyone was involved and ready to participate actively in the discussions, a draw was held in each class to determine the presenter, and students who had already presented were not included in the subsequent draw. This format allowed students to read beforehand and be prepared to discuss the content, promoting mutual understanding and collaborative learning, which are fundamental aspects of the success of the flipped classroom. Each student had between 20 and 30 minutes for their presentation.

[4]https://atlasti.com/

3.3 Suggested Tools for PWs

To carry out PW1, the students were instructed to use the Porifera (Campos et al., 2022) tool. Porifera is a web application available at porifera.app.br. It is aimed at researchers who will carry out SMS or Systematic Literature Reviews. Campos et al. (2022) point out that Porifera has some advantages, such as the inclusion of the Kappa coefficient calculation (Cohen, 1960). Kappa is a Concordance Test that assesses interobserver or intraobserver reliability (reproducibility) for nominal categorical variables (Cohen, 1960).

The tool supports SMS planning as well as execution. In the planning definition, the researcher can indicate the objectives, search strategies, search sources, and criteria for selecting primary studies. For the objective, the tool suggests adding it based on the GQM and also adding the main research question. For the search strategies, the tool suggests using PICOC (Population, Intervention, Comparison, Outcome, and Context) to help form the string. As for research sources, the tool allows you to add the digital libraries that will be used. Finally, the selection criteria (inclusion criteria and exclusion criteria) will be used in the article selection process, where the tool supports adding them and consulting them when necessary.

To import the digital library files into the tool, Campos et al. (2022) recommend using the Bibtex format. Another advantage of the tool is that during the import process, it displays records with incomplete data that need to be checked and, if necessary, adjusted.

The SMS is run based on the imported files, i.e. on the list of publications. The selection of articles is organized into two phases (two filters), indicated in the tool as “First” and “Second”. Thus, the researcher will select a criterion and optionally add a comment on their evaluation. When there is agreement between the evaluation criteria, the tool will prompt the researcher to confirm this. If there is a disagreement between the researchers, the tool will show the disagreement between the evaluations. The authors also considered that it is not possible to view the reviews of other researchers before carrying out your own review. Therefore, the researchers will discuss and finally come to a consensus. According to the authors, this is another distinguishing feature of the tool, where it allows the stability and evaluations of each researcher to be carried out.

During the selection process, Porifera displays a dashboard to keep track of information about each selection phase. It also displays the concordance index and reliability index, as shown in Figure 3.

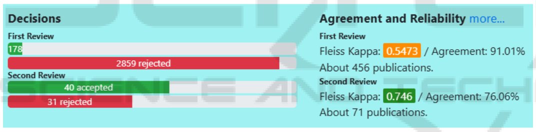

Figure 3: Porifera software (in Portuguese).

For the PW3, it was suggested that two tools be used for the study’s statistical tests: SPSS, available at https://www.ibm.com/br-pt/spss and/or R, available at https://www.r-project.org/.

The Statistical Package for the Social Sciences (SPSS) is a statistical software program that allows you to analyze data, create graphs and reports, and perform statistical tests. One of the advantages of using SPSS is that it allows you to import and export data from other programs, and can merge files with different subjects and variables. It was developed in the 1960s and is currently maintained by IBM and is known as IBM SPSS Statistics (Verma, 2012).

The disadvantage of using SPSS is that it can be challenging for beginners, as you need computer skills to manage it fully (Verma, 2012). We have added an example of the interface found in this software (Figure 4).

The R software is a free software environment for statistical computing and graphics (Figure 5) (Chambers, 2008). One of its distinguishing features is that

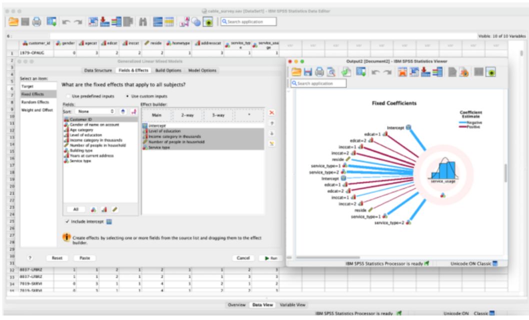

Figure 4: SPSS software.

it compiles and runs on various platforms such as UNIX, Windows, and MacOS. The software supports various statistical techniques such as linear and nonlinear modeling, classical statistical tests, time series analysis, classification, clustering, and graphics, and is highly extensible (Chambers, 2008).

One advantage of using the software is the ease with which well-designed publication-quality graphics can be produced, including mathematical symbols and formulas where necessary (Chambers, 2008).

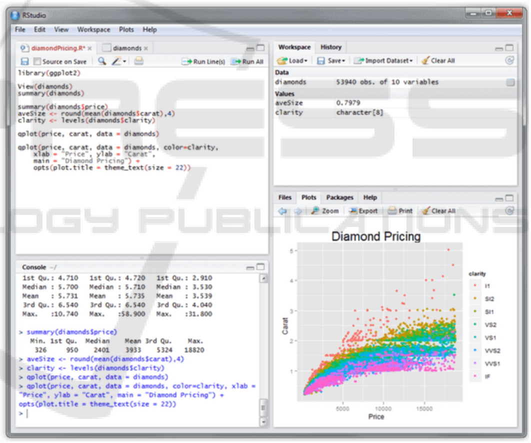

Figure 5: R software.

And for PW4, the Atlas.ti tool available at https://atlasti.com/ was suggested (Figure 6). Atlas.ti is a qualitative data analysis software that can be used to search and analyze abundant textual, graphic, audio, and video data.

The tool helps organize and manage data systematically and creatively, helping to optimize the analytical process. One of Atlas.ti’s differentials are that it has features such as advanced coding, multimedia analysis, visualization, and real-time collaboration.

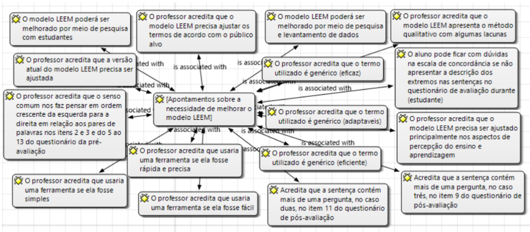

Figure 6: Atlas.ti software (in Portuguese).

4 RESULTS: PERCEPTIONS AND MEASURES TAKEN

4.1 Main Difficulties of Understanding

Regarding the main difficulties observed during the development of the PWs, it is important to highlight that in PW1, students faced challenges in using the GQM method, particularly with the phrase "for the purpose of". To address this issue, the teacher provided in-class examples to help clarify the students' understanding and reinforce the correct application of GQM. Another difficulty arose when students were required to use the PICOC framework to develop the search string. To assist with this, the teacher used the students' own topics to demonstrate how to formulate a proper search string, familiarizing them with the PICOC approach and its relevance to the task.

Additionally, some students struggled with understanding the purpose of conducting a Systematic Mapping Study (SMS) and the justification for its importance. To help address this, the teacher introduced relevant article examples, guiding students to reflect on the significance of the SMS in the context of their research topics. In PW4, the main difficulties were associated with the qualitative analysis process. During the presentation on qualitative coding, some students had trouble grasping the concepts of open and axial coding. To aid their comprehension, the teacher conducted a hands-on coding exercise on the whiteboard, encouraging all students to participate. This interactive approach helped improve their understanding of the coding process.

Another difficulty reported by students was in using the suggested tool for qualitative analysis, Atlas.ti. One student had trouble finding the option for axial coding within the software. To cope with this, she resorted to using alternative methods. For example, another student found it easier to use spreadsheets for both open and axial coding instead of the Atlas.ti tool, as they felt more comfortable with this approach. These challenges underscore the importance of offering additional practice, demonstrations, and flexibility in tool usage to ensure that students can effectively engage with the methodologies and tools being taught.

4.2 Completeness and Evolution of the Students in Each PW

Regarding the completeness and evolution of the students in each Practical Work (PW), an analysis was conducted of both the pair (PA) and the four students who completed the PWs individually (P1, P2, P3, and P4).

In PW1, several items were either not described or described incompletely in the reports. These included: the need for the SMS topic (PA, P2), the study's aim according to the GQM framework (PA, P1, P4), the search string according to the PICOC framework (PA, P1, P3, P4), the selection of data sources (P1), the justification for choosing these sources (P3, P4), the description of restrictions associated with the study (PA, P2, P3, P4), the selection of languages (P2), the selection procedures and criteria (P1, P2, P3, P4), the execution of the pilot study (P1, P2), modifications and/or additions to selection criteria (P1), defining the data extraction form (PA, P1, P3, P4), running the search with the string (P1), selecting the 30 articles to export in Bibtex format and importing them into Porifera (P1), running the first filter (P1, P2, P4), running the second filter (P1, P2, P4), interpreting the concordance and reliability indices (P1, P3, P4), and extracting an article that passed the second filter (PA, P1, P3, P4).

In PW2, the following items were either missing or incompletely described: the objective of the study according to the GQM framework (P3, P4), the formulation of null and alternative hypotheses (P3, P4), the selection of dependent and independent variables (P3), how these variables will be collected and/or calculated (PA, P1), the specification of the study design (P1, P4), the definition of the instruments (P1, P3), the assessment of threats to validity (P4), and the description of personal characteristics of the pilot study participants (P1). For PW3, all the students who completed the PW did so fully, but P2 and P4 did not carry out this PW. In PW4, only P1 completed the task but did not present his study, while the other students completed it as expected.

These results show that in the first two PWs, the pair of students failed to complete certain items—six items in PW1 and one item in PW2. However, for the other PWs, the students completed all the required tasks. This led to some conjectures: the pair may have faced challenges in communication and collaboration, which were addressed during the course to ensure that the subsequent PWs met all the expected requirements. Another possibility is that the first PWs (1 and 2) were more complex and required more time to complete, which may have contributed to the students' struggles. As the number of items increased in each PW, the students dedicated more time and effort to ensure completion.

On the other hand, when analyzing the students who completed the PWs individually, it is evident that they faced more challenges in completing the tasks. It was only in PW3 and PW4 that these students were able to complete nearly all the required items. This suggests that, as undergraduates, the individual students may have struggled more due to the heavy workload of the PWs. In contrast, the pair of students found it easier to manage the workload and complete most of the tasks. Therefore, for future iterations of the course, it is recommended that students be encouraged to complete the PWs in pairs, which would likely enhance their ability to manage the workload effectively and complete tasks more efficiently.

Finally, one student who worked in pairs shared his experience, stating: "I found it more productive because when I had doubts, I would ask my partner, and he would either have the answer or help me figure it out. This collaboration made the subject more useful". The student also emphasized the importance of the practices carried out in the course, saying:' 'This subject is something that I believe should be mandatory in the program because reading and understanding articles, conducting tests, and understanding statistical and qualitative analysis are essential skills in academia."

5 LESSONS LEARNED

The results presented in Section 4 highlight key lessons from the experience with the Topics in HCI course. Firstly, the course's importance was reaffirmed by positive student feedback, emphasizing the relevance of the PWs in developing essential skills. Conducting the PWs in pairs proved beneficial for undergraduate students, as it facilitated knowledge exchange and encouraged discussions that deepened their understanding of the topics. Allowing students to choose between working in pairs or individually was valuable, but it also underscored the need for greater guidance for those who opted to complete the PWs individually.

Another significant challenge was the students' difficulty in using GQM to define research objectives and PICOC to construct the search string in PW1. To address this, the instructor implemented a practical exercise with examples from different topics. This experience underscored the importance of providing detailed instructions and additional practice. A recommended approach involves presenting each concept individually on the whiteboard, followed by interactive activities with post-it notes to reinforce understanding.

In PW4, students also faced difficulties with open and axial coding. To improve comprehension, the instructor used a practical approach, illustrating the coding process on the whiteboard. This method proved effective and highlighted the necessity of diversifying teaching strategies. While slide presentations and digital tools were useful, interactive and hands-on teaching methods provided a more profound grasp of the concepts.

Regarding the use of Atlas.ti for qualitative analysis, students encountered various challenges. Some struggled to utilize all the tool's features, while others chose alternatives such as spreadsheets or visual aids like color-coding to differentiate themes. These observations reinforce the importance of offering flexibility in the selection of methods and tools for completing PWs. The key takeaway is that while specific tools can be valuable, ensuring flexibility in analysis tools is essential to accommodate different learning preferences and enable all students to complete their tasks successfully.

Finally, this study provides insights into the Informatics in Education community by emphasizing the need to adapt teaching methodologies to students' diverse needs. The analysis of challenges and the strategies implemented can serve as a foundation for improving courses that involve practical learning and scientific inquiry, offering guidance for educators seeking to enhance their pedagogical approaches.

6 CONCLUSIONS AND FUTURE WORK

The Topics in HCI course aimed to train students in conducting both primary and secondary studies. Analyzing the results of the four Practical Works (PWs) allowed us to identify critical challenges and key lessons learned.

The findings reveal that students encountered different difficulties in each PW. In PW1, challenges arose in applying the GQM approach and formulating the search string, which required practical interventions and additional examples from the instructor. In PW4, students struggled with qualitative coding, particularly in using the Atlas.ti tool and performing open and axial coding. Practical interventions, such as whiteboard exercises and classroom discussions, enhanced students' understanding.

Student progress analysis indicated that working in pairs was more beneficial for undergraduates, as it fostered greater productivity and collaboration. In contrast, students who completed the PWs individually encountered more difficulties, leading to incomplete work in some cases. This result underscores the importance of encouraging pair work as an effective strategy for improving student performance.

A key limitation observed was the difficulty in using the proposed tools and methodologies, such as Atlas.ti and GQM, which remained significant obstacles for some students. These difficulties may have impacted their performance and comprehension of the PWs. To address this, we recommend incorporating additional hands-on exercises and targeted demonstrations of the tools and methodologies used. Furthermore, providing extra support for qualitative analysis tools and fostering a more structured collaborative environment could enhance both teaching effectiveness and student learning in future course iterations.

Building on the lessons learned, a future direction involves defining a set of guidelines based on these insights to assist educators in structuring similar courses. These guidelines would provide practical recommendations on instructional strategies, tool integration, and collaborative learning approaches, helping instructors navigate common challenges and optimize student engagement and learning outcomes.

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