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IMPACT OF PAIR PROGRAMMING ON NOVICE PERFORMANCE IN ONLINE FIRST PROGRAMMING LANGUAGE (FPL) DURING COVID-19

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Abstract:

The intention of this research is to investigate effectiveness and impact of pair programming on the performance of novices in first online programming language like C during covid-19 pandemic. This study analyzed the efficacy of pair programming used as a teaching tool in online introductory programming language. It was found that pair programming technique in teaching FPL has considerable impact on grades, learning, error handlining, cognitive programming and collaborating learning of novices in CS1.This paper reports on the final results of novices indicating their progress in first online programming language course. It is indicated that collective erudition had valuable impression on novice learning outcomes thus making learning first programming language more interactive, appealing and exhilarating. We were concentrating on how pair programming has affected performance, retention, dropout rate, female and male performance of novices in online programming course. We inferred that the treatment group with pair programming teaching approach performed better in programming and produced better programs with good understanding of error handling and recovery and their confident level much better in their solutions and relished with completion of their assignments and achieved better grades than the control group, in which no pair programming teaching method was used. The results of analysis indicate that in experimental treatment group pass rate was high, female novices performed more effectively as compared to non-pairs control group.

Keywords: First programming language, pair programming, novice, solo-programmers

INTRODUCTION

FPL is most of the hot discussion for many decades. Most of the time is agreed that FPL is very important and effects education of students on programming [17] and [25]. Over the years many researches are conducted on how to teach effectively first programming language to newly enrolled students in computer science. Novices fight hard battles to learn programming in their first semester, they are often crest fallen and leave the discipline and it was much elevated during covid-19 pandemic in online classes. Programming learning is hard nut to crack for novices with diverse background having little or no knowledge of programming and educators feel cumbersome and struggle hard to teach programming to novices in undergraduate computer science programs and it is still a challenge to give class online. Novices are reluctant to learn programming from scratch and instructors feel burden how to prepare novices in FPL, as FPL has considerable impact on performance in later programming subject. It has been observed that students fail to learn programming even by their final semesters and are at verge of poor performance in their programming and often fail to acquire good programming, problem solving and cognitive skills. There is high dropout rates and abrasion in introductory programming courses.

It is acknowledged that programming tremendously intricate and problematic rational activity and require considerable effort from the students in their first programming course and it is often a challenge to teach programing online with little interaction and teacher also scuffle to teach programming to novices. Programming is very difficult for newly enrolled novices [7]. There is lot of cognitive load on novices [2], and it is difficult to read, track, write and design simple programs, students fight hard battles to handle simple programming assignments [6], [12]. Beginning programmers are often perceived by perception that they understand everything in lecture and also comprehend what is requirement of assignments, on the contrary when they try to write their program they are in the middle of nowhere and require further guidance from their teachers [3]. For the first-year undergraduate it is very difficult to develop analytical and problem-solving skills to learn and understand programming alone [15] pair programming is an approach which require two students to work collaboratively on single computer on the same program or a piece of code [21], [22]. Studies reveal that there is great deal of effectiveness of pair programming in the programming learning process of students [19]. the results of experiment conducted by [22], [23] discovered that students working in pairs produced higher quality code more proficiently and swiftly then non-pairs. The novices who worked in pairs in the beginning programming course have higher retention rate, score good grades, pass their exams then non-pairs [8].

Over the recent years lot of preference has been given to extreme programming (XP) and collaborating learning is boasted [8] [20] and [21]. Pair programming has considerably enhanced productivity, knowledge transferred, leaning and self-esteem with better understanding of errors and develop program with fewer errors [22], [23], [24] & [4]. It has been indicated by [13] that in pair programming roles of pairs is one driver and other is navigator. Both driver and navigator influence teaching, learning and face challenges and benefits related to programming together as a team, pairing partners increase their practical knowledge and also members share knowledge which is explicit aim of pair programming [11].

The pair programming requires two programmer work close together in the form of a team on the same project, algorithm design, code, or test together side by side, in which one is said to be "driver", who is responsible for creating code, governing keyboard and mouse where as other is " non-driver" who is continuously assess data entered in order to identify potential preemptive and planned deficits, which include syntax errors, semantic, logical errors in the program. After some time, partners switch roles, code produce by one companion is castoff or swotted collaboratively before amalgamation [8] and [9].

Two surveys were conducted on the benefits of pair programming by [14] and [1], [10] on developers and managers in 42 Australian companies and web-based survey of 487 Microsoft developers, the results revealed that transfer of knowledge is one of most professed objective of pair programming.

DESIGN METHODS

The main aim of this study was to affirm impact and effects of remote pair programming during lockdown and pandemic on the performance of novices in FPL online course and how pair programming has deep significance on their programming ability and final scores, along with retention in computer science, glimpse on dropout rate, gender wise novice performance in CS1 FPL and influence of PP on perseverance, insistence and performance of female students. It promotes collaborative learning and hence induces high degree of efficacy and confidence in programming. The participants were from CS1 undertaking online course of "introduction to programming" and C language as FPL. The total number of participants was 148, divided into two groups control and treatment groups. In treatment group pair programming teaching method was used to teach FPL.In treatment group total number of the participants was 70 out of which 7 were female novices and rest were male and in non-pairs control group total number of participants was 78 with only 5 females and rest were males. The partakers in both groups were novices who attempted online FPL course during pandemic, enrolled in computer science and information technology majors, at the university of Baluchistan during 2019-2020 academic year.

Pair programming was used as a teaching technique to teach FPL to the novices enrolled in CS1 and they were required to ample their class assignments and programming assignments using pair programming where as other non-pairs group required to work independently alone on their assignments and in-class practice programs.

In the treatment group pairing was done randomly with keeping in view class performance of novices, the group included blend of feeble, sluggish learners and sharp bright learners with good programming skills. Some of the partners were changed and reassigned to others and were allowed to work in collaboration on the basis of demographical factors like living in dormitory/hostel with same background, language and remote areas. The novices constantly were required to stay with the same partner throughout the semester. Data was combined and compared from the non-pairs control group with the pair programming treatment group.

Novices were assigned different programming assignments in-class which they were required to complete within class and out-class assignments were required to be submitted and presented within the period of one week. Attendance required in both groups was obligatory.

Students in both groups were required to submit 11 home assignments and 10 to 15 in-class practice programming projects, both types of assignments were given scores for functionality, rate of error and their correction and error handling, readability and also time estimated time to write, execute and debug particular code. Novices were required to submit their error logs in different programming assignments in both the groups. Grip of programming knowledge alone and in pairs has deep impact on efficacy, enthusiasm of novices. Students working alone were dejected and crest-fallen with less efficacy in the solutions they have developed, most of the time they were noticed struggling with error correction and on average spent more time then pairs, it has been noticed that non-pairs group were often complaining they can't comprehend what was taught in class during their projects.

Novices' despite of the fact submitted and completed their assignments in FPL in pairs, each one of them attempted their terminal exams individualistically. Terminal results evaluate novice's problem-solving skills, programming knowledge, error handling, debugging and capability to transcribe new-fangled code and programs. Information was collected regarding their final scores in FPL which were later compared and contrast for both the groups pairs and non-pairs.

RESULTS

Course outline of FPL was analogous in both the groups. Postulation of this study was set keeping in sight speculative preparation of novices to succeed. Terminal scores for both the groups were collected to assess our postulation that academic achievement and performance of novices in FPL is influenced by pair programming effectually.

3.1. Completion, Pass Rates, Drop-out Rates, Retention, Failure Rate

The speculative achievement and performance of novices in FPL is forthrightly indicated by triumph of completing and passing the online FPL course during covid-19.

Table1. Insertion

The comparison of treatment pair-programming group to non-pairs control group reveal that pass rate was high in case of pairs then non-pairs, the dropout rate is high in non-pairs as compare to pairs. Comparison among pass rate, drop-out, failure rate and students who left clearly indicate how effectively pair programming has impact on the academic performance of novices in online FPL course along with high retention rate. It has been proposed that "pair-pressure" is the main reason for high course completion rates in pairs then non-pairs suggested by [22[, [23] and [24]. The study conducted by [8] and [9] that sticking thing was not the reason for pairs to complete and pass FPL however a large proportion of pairs were able to acquire enough programming knowledge which was required to pass the course. The conclusion from overall performance in terminal exams explicitly ensure affirmation of past researches that collaborative learning enhance interest, better retention, low drop-out rates and over all good academic grades and performance of novices.

3.2 Performance in First Programming Language (FPL)

It was suggested by [16] that learning programming is la-di-da by lack of confidence, interest, low self-efficacy and there is higher rate of females who left the discipline due to aforementioned traits. Female students in both the groups performed better than males and from results it is inferred that despite of being minority in number as compare to male counterparts in CS1 female novices performed better both in solo and in pair programming, their overall academic achievement was better than males, pass-out, drop-out rates was much better than males and their scores in final exams were better than males. It is very astonishing to infer from results that females in pairs performed better than non-pairs with high scores, better grades, accomplishment and interest along with good programming and problem-solving skills. The results are illustrated in the following figures 1, 2, 3,4

Fig 1. Insertion

Fig 2. Insertion

Fig 3. Insertion

Fig 4. Insertion

It is clearly indicated from the fig. 4 and fig .5 that novices in pairs perform better than non-pairs, more than half of the group scored good grades then non-pairs, maximum score of pair novices is better than non-pairs, most of non-pairs just passed the course and failed to achieve higher grades.

It was suggested by [16] that learning programming is affected by lack of confidence, interest, low self-efficacy and there is higher rate of females who left the discipline due to aforementioned traits. It is very astonishing to infer from results that female students in both the groups performed better than males and from results it is inferred that despite of being minority in number as compare to male counterparts in CS1 female novices performed better both in solo and in pair programming, their overall academic achievement was better than males, pass-out, drop-out rates was much better than males and ensured deep learning then surface learning, with high confidence, much better degree of perseverance in CS. Female novices scores in final exams were better than males. Females in pairs performed better than non-pairs with high scores, better grades, accomplishment and interest along with good programming and problem-solving skills.

3.3 Female Performance in First Programming Language (FPL)

Fig 5. Insertion

Fig 6. Insertion

Females in pairs performed better than non-pairs with high scores, better grades, accomplishment and interest along with good programming and problem-solving skills. The final exams were taken by both groups autonomously, the Figs 3 and 4 depict individual final exam scores reflect the extent to which they have learned programming.

Fig 7. Insertion

By the completion of FPL, female novices in pairs performed better with elevated interest. Quality of programs produced by them was much better, with fewer errors and more readable than non-pairs females. Average scores of paired females are much better than non-pairs.

Table2. Insertion

Table3. Insertion

The T-test conducted on the performance of subjects shows that there was a significant difference on the score of pair group and solo group such that **t-value = 1.67** and **p < .05**.

It is concluded that over all pairing is useful, handy for majority of novices in CS1.Through this research it is certain that pair programming is specially advantageous for novice women in their first semester as PP comprehensively addressed numerous substantial aspects which hinders participation and progress of female novices in computer science and programming . It was suggested by [20] [9] that pair-programming helps females to learn programming easily and communal fauna of pair-programming promote female novices to comprehend that programming is not the modest, competitive activity neither it is informally segregating commotion that they ever imagined and continue their leaning of programming with perseverance hence ensuring creativity, persistence and effective software development in computer science majors and encourages females to pursue their potential programming careers in CS.

CONCLUSION AND FUTURE WORK

The results of this study specify that pair programming during pandemic in online class has elevated learning and develop keenness and curiosity for both male and female, and that these intensifications are supplementary exaggerated for females. Females dependably misconstrue their level of computer eloquence relative to male novices. We assume that PP will benefit females students more in pairs and they develop potential skills to overcome barriers in their first programming language course, when females learn programming in duos with the relatively unequal skills, they are more open to accept and change their roles if skills are enhanced .The results of this research indicated and suggests that pair programming plays a very important role in engaging, promoting, nourishing interest, keenness of novices whether male or female in programming and hence ensuring effective development of software and promising future in computer science.

The results of this study provide effective evidence that pair programming effects performance of novices in their first programming course effectively and later on it will play significant role in later programming oriented subjects and has deep influence on novice performance and is one of most effective pedagogical tool that has deep impact and effect on the learning capability and performance of novices both male and females in CS1. It reflects that PP ensures completion of the course with high retention, less drop-out and high pass rate and plays a very momentous role in perseverance, tenacity in CS majors. Novices who were paired showed high efficacy in programming with high degree of error resolution, good problem solving and produces better quality programs then non-pairs. We assume that these results will inspire mentors to practice pair programming in CS1 but also in later programming subjects.

Pair programming stand-in as effective tool learning programming for female novices and increase their skill in programming although PP has deep effect on the performance of both male and female novices. PP has significant impact on error resolution, diagnosis of errors, understanding of errors, working in different IDEs, identifying classes of errors in programming, effective debugging skills of novices is left for future work.

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FIGURES:

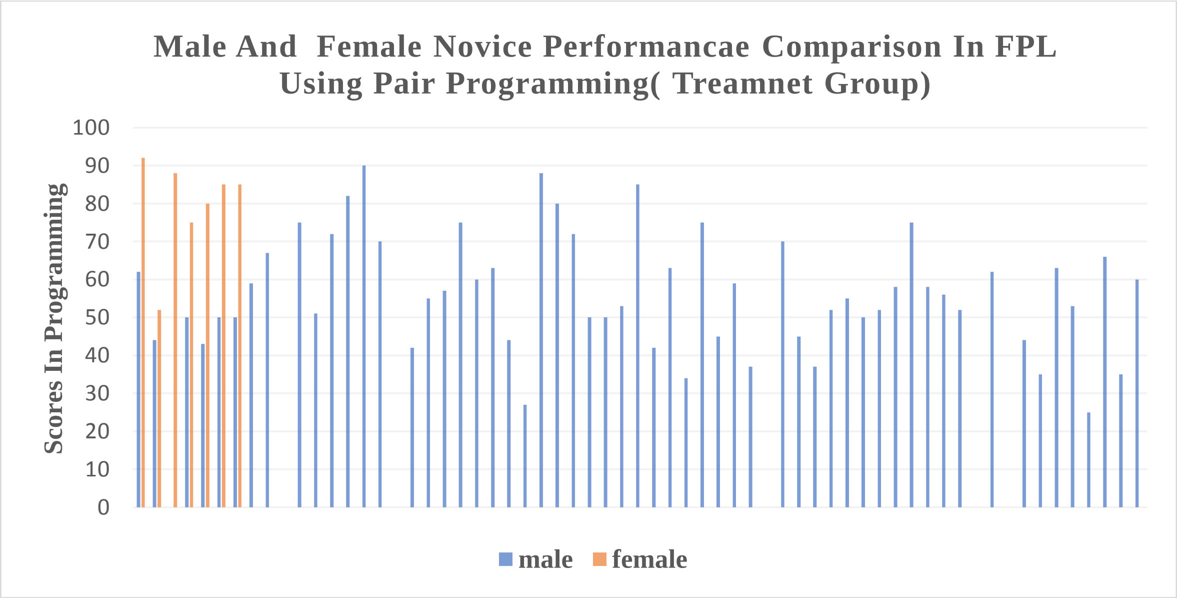

Fig1. Comparison of performance of male and female pairs in FPL

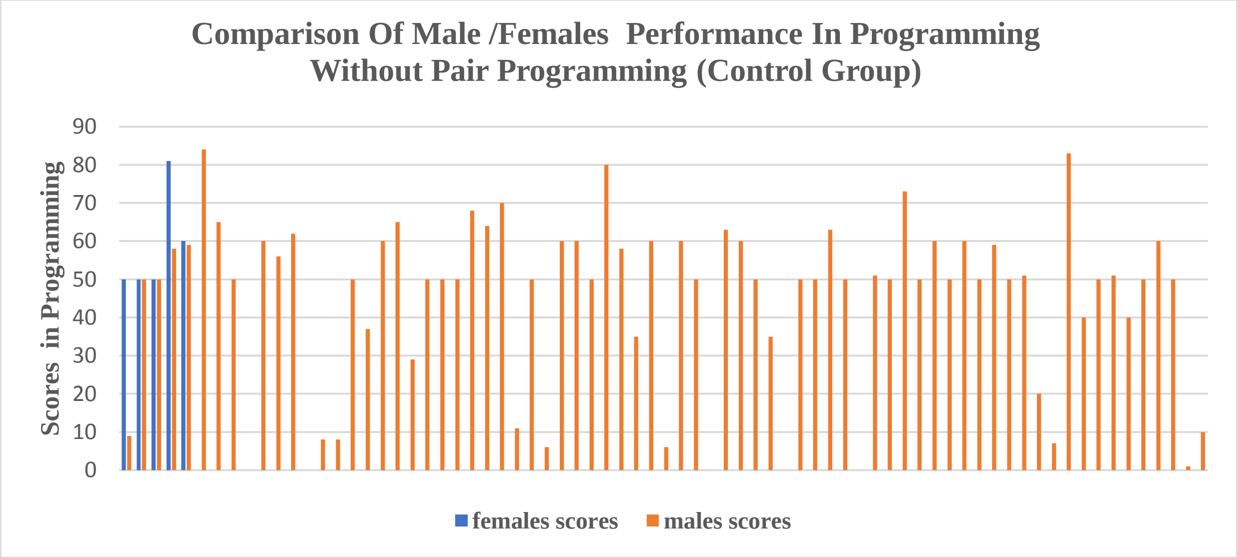

Fig2. Performance of male and female non-pairs in FPL

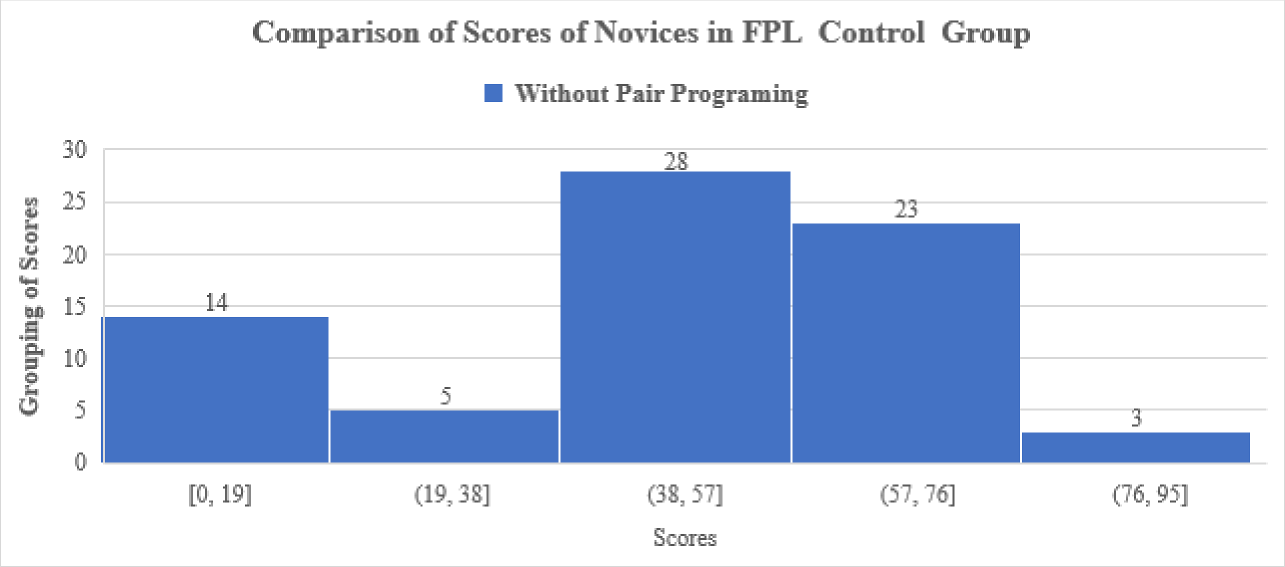

Fig 3. Comparison of final term scores of both male and female non-pairs control group in FPL

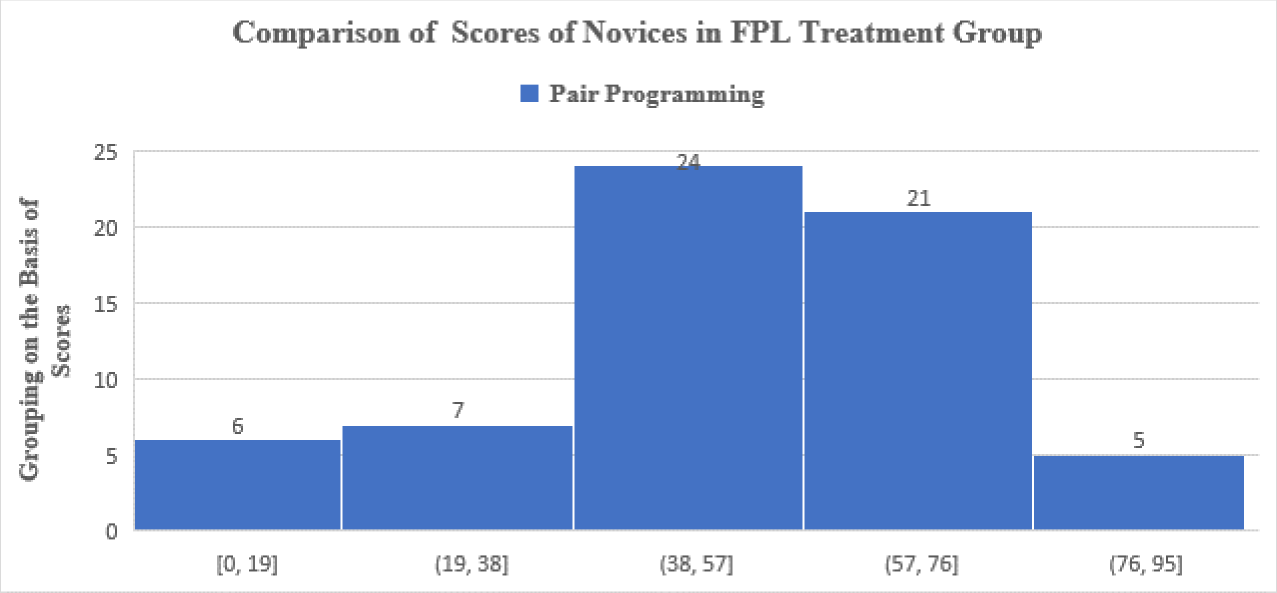

Fig 4. Comparison of final term scores of both male and female pairs in FPL (treatment group)

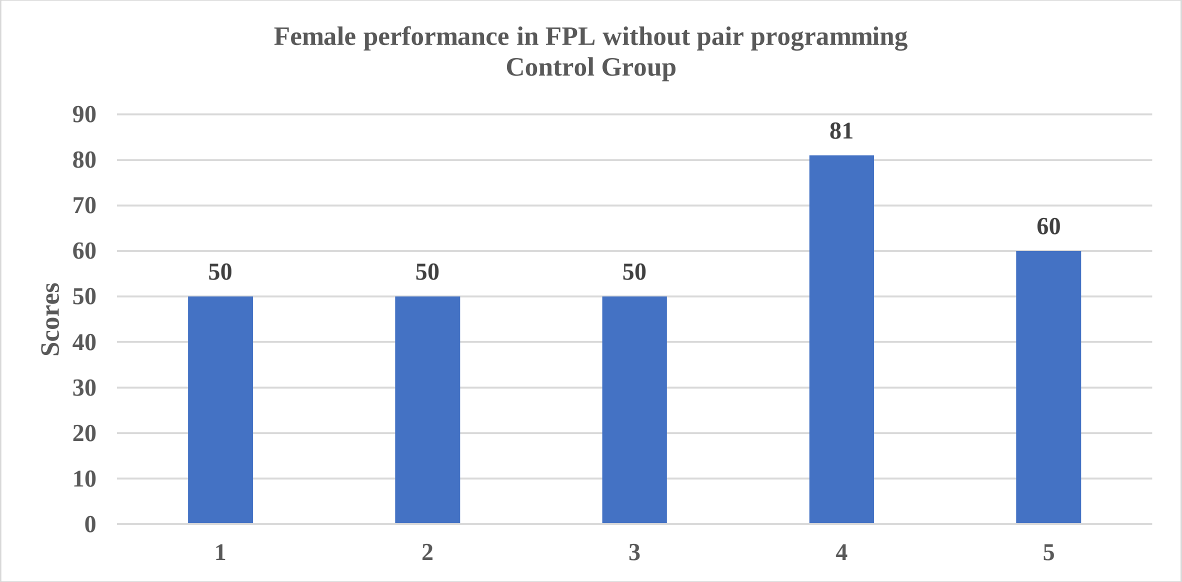

Fig 5. Comparison of female novices without pair programming in control group

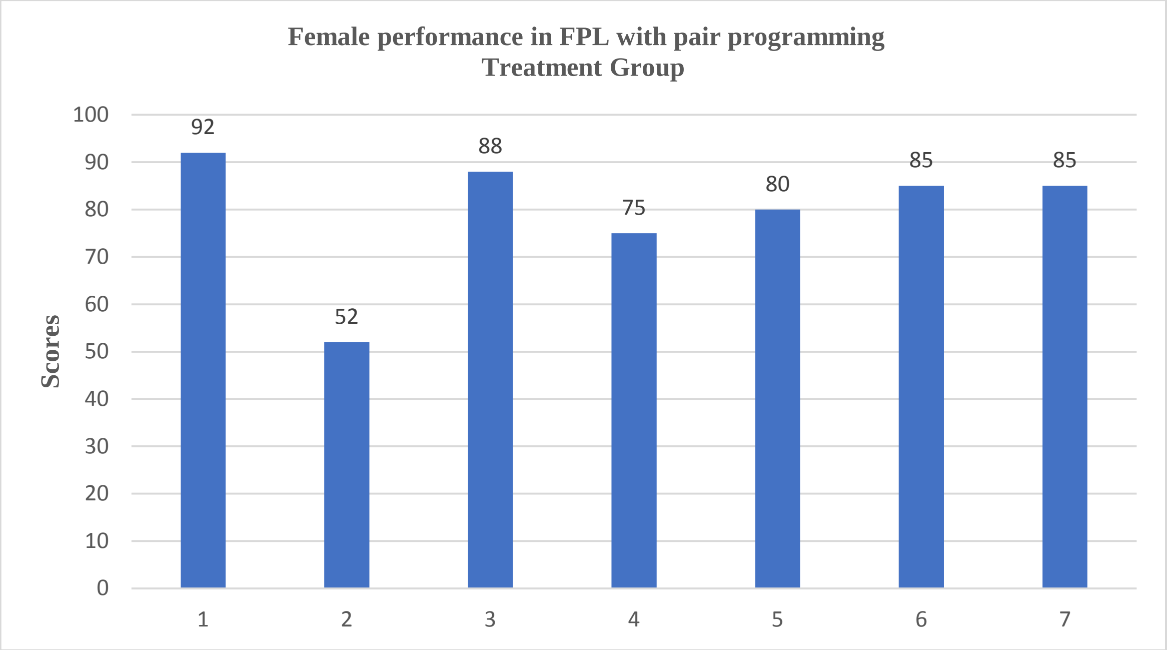

Fig 6. Comparison of female novices with pair programming **(treatment group)**

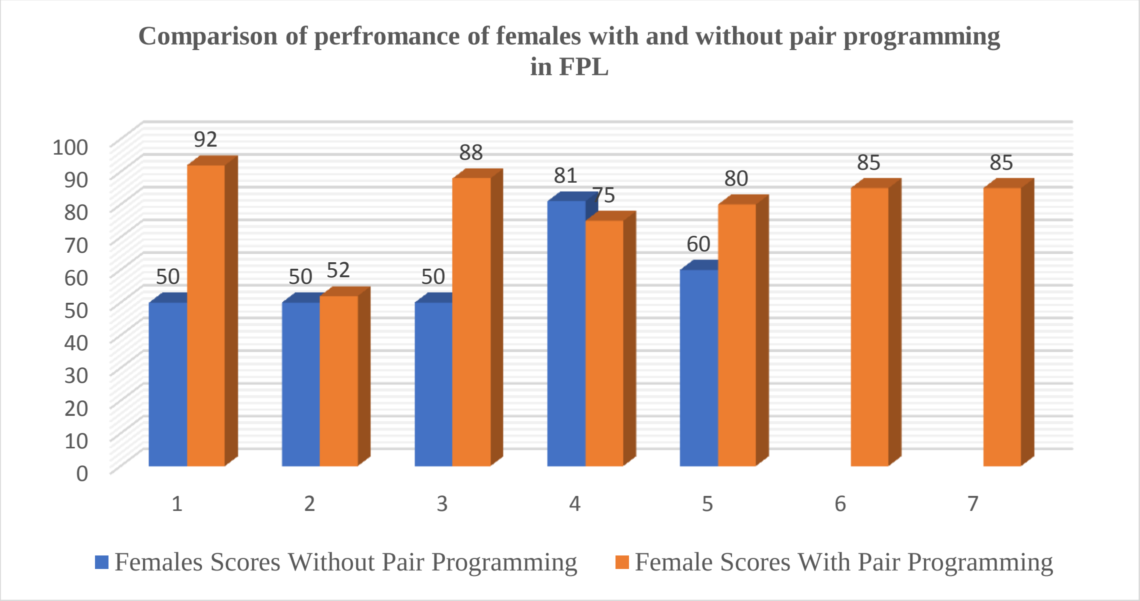

Fig.7. Comparison of females in both the groups

Tables:

Table 1. Comparison table pass-rate, drop-out, retention and failure rate

	Total Number of Novices	**Pass-Rate**	**Drop-out**	**Retention**	**Failure-Rate**	**Students who did not took Exam**
Treatment Group (Pairs)	N=71	80.3%	19.7%	87%	40%	4
Control Group (Non-pairs)	N=78	73.0%	26.9%	71%	46%	6

Table 2. Comparison of average scores of treatment and control groups female novices in FPL

Control Group Females (non-pairs)	N=5	**Treatment Group Female (pairs)**	N=7
Average score	58.2	**Average Score**	80

Table 3. Comparison of average scores of control and treatment male novices in FPL

Control Group Males (non-pairs)	N=70	**Treatment Group Male (pairs)**	N=63
Average score	45.0	**Average Score**	52.1