Using iWorx 214 System to Stimulate Innovative Learning in a Medical Science Laboratory

Feng Feng, April Horstman-Reser *and* Mary Lee Lusby

***Abstract*—From traditional lecture and lab teaching to computer-based activities, technological advances have been applied to health care sciences education in an effort to enhance student learning. As educators, we facilitate the students' journey towards independent learning in accordance with current standards in science pedagogy, but must also help students learn how to use technologies in order to seek, organize, analyze, and apply information appropriately. We implemented iWorx which provides computerized data recording and analysis using multiple transducers into the anatomy and physiology course to meet the pedagogical objective of providing students with active learning exercises that extend beyond topics covered in the lecture portion of the course, while circumventing problems encountered when creating an introductory-level medical science lab. We found that performing simple activities such as ECG, EEG, EMG, and spirometry by using iWorx increases students' comfort levels, knowledge and experience levels, and interest levels of laboratory related skills. We observed these increases, which were demonstrated in comparisons between scores in students' lab activities, while using iWorx especially when students were applying the scientific method to physiological issues, using computer-based laboratory equipment, and demonstrating knowledge of scientific methodologies. Designing hands-on learning and new kinesthetic activities improves conceptual learning in cardiovascular, neurological, muscular, and respiratory physiology in the lectures. The student relative lab practical scores improved significantly. Pedagogical objectives can be met in an overwhelmingly positive lab experience for students when health sciences faculty use computer-based technologies.**

***Index Terms*—education, computer-based technology, iWorx, anatomy and physiology**

I. Introduction

ONE of the most important aspects of being an educator is developing the skills needed to successfully organize and simplify difficult concepts presented to students. This is especially true for students who will soon work with patients in a clinical field. New technologies on college campuses influence the ways in which college courses are taught and students learn. Technological tools can help students learn and study more effectively. Hard-to-visualize physiological concepts are easily explained with available software. Yet, few college-level instructors utilize new educational technologies effectively in their courses (Bradshaw, Steinman, & McCarley, 2002). The hands-on equipment and software have become valuable teaching tools and student resources. Unlike a traditional lab that uses preset procedures to demonstrate principles and lecture concepts, our lab is structured to develop students' abilities to apply science as a clinician. Our goal is to use numerous technological tools to train talented students to accomplish clinical work within the cardiovascular, muscular, neurologic, and pulmonary physiology fields.

Introducing computer based activities into traditional labs will promote student's engagement. The introduction of activities into lectures can significantly improve recall of information; in addition, extensive evidence has been reported about the educational the benefits of student engagement (Baylor & Ritchie, 2002). From a conceptual perspective, the traditional approach to teaching seen in many classrooms can be considered "misaligned" and ineffective (Cohen, 1987). In these cases, course objectives are not clearly aligned with what is actually occurring in the labs. If educational technologies are to be used effectively, their use must be considered with respect to course objectives, not just for the sake of using the technology. When course objectives are aligned with the learning experience that incorporates new technologies, it can lead to effective teaching, with a comparatively low degree of instructional effort (Cohen, 1987). In addition, such alignment can result in a higher (or deeper) level of learning and become even more effective as the complexity of course material increases (Baylor & Ritchie, 2002).

Through the use of the iWorx 215 system, a computer-based physiological recording system, we redistributed the lab time to enhance the student learning experience. The students spent more time in the discussion and developed experimental hypothesis, analyzed data and also drew the conclusion. This

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A. Horstman-Reser is with Nebraska Methodist College, Omaha, NE 68114 USA. (e-mail: april.horstmanreser@methodistcollege.edu).

M. L. Lusby Feng is with Nebraska Methodist College, Omaha, NE 68114 USA. (marylee.lusby@methodistcollege.edu).

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resulted in a higher level of student understanding from the lab learning experiences.

II. Background

Nebraska Methodist College (NMC) is a small (950 students), private college. In the last year, approximately 200 students completed the human anatomy and physiology laboratory in a semester-length course. Students attended 11 weekly 2-hour faculty-facilitated laboratory sessions. The iWorx214 system was introduced to perform laboratory exercises that integrate students' knowledge into a true learning experience.

In determining the best forms of educational technology to use, the lab dynamics and learning objectives become critically important. For the courses the researcher teaches, each one presents its own limitations for integrating technology. Anatomy and Physiology I and II (AP I and AP II) are survey courses that expose students to the dynamic interdisciplinary nature of medical science, with an emphasis on the 11 human systems. The use of iWorx214 in this course is influenced by a small lab group size of 10 to 16 students and a schedule of 2-hour labs along with a 3-hour lecture each week. The course focus on finding physiological changes of neuronal, muscular, cardiovascular, and respiratory systems and the abilities of these systems to regulate the activity of other physiological systems.

This complementary approach across both AP I and AP II at NMC provides students with a consistent curriculum of repetition and practice of the knowledge, skills, and abilities involved in doing science while challenging them with the opportunity to continue to more advanced understanding and skills. In turn, the human anatomy and physiology laboratory provides a foundation for complex exercises and a higher-level physiology lab experience. In addition, this approach will help to refine teaching so that it fosters active learning that matches the needs of students, particular courses, personal teaching styles, and faculty members' personalities. This will mean that faculty members also become learners in the classroom.

Tyler and Voneida (1992) developed the Graphic Brain computer software to better convey spatial and temporal dimensions of functional neuroanatomy and neuronal physiology to medical and graduate students taking neuroscience. They found that the computer-assisted software led to more efficient use of teaching time, that the students reported they understood the concepts more quickly and easily, and that the students demonstrated better mastery of the course material. Bradshaw, Steinman, and McCarley (2002) recently added a Biological Mind section to ePsych (http://epsych.msstate.edu), which explains many of the same concepts highlighted by Teyler and Voneida to introductory-level students. Solomon, Cooper, and Pomerleau (1988) also used simulation programs to study a variety of properties of neuronal membranes (e.g., action potential, excitatory postsynaptic potentials) as an optional activity in a sophomore-level course in neuroscience. They found that 80% of the students who used the simulations reported that the programs helped them to understand properties of the resting potential. Other researchers have used neuroscience laboratory exercises to minimize costs and to demonstrate the direct application of neuroscientific principles to humans (Thomas & George, 2003). Lennartz (1999) developed a laboratory exercise using electromyography in an undergraduate introductory neuroscience course to highlight electrical signal changes. The students studied changes in the electromyogram record with changes in their muscle tension and limb movement. On an evaluation, the students gave largely positive ratings to this exercise. In their written comments, the students also indicated that they liked the fact that humans served as participants in the exercise.

Using the iWorx data acquisition and analysis system (http://www.iworx.com), Griffin (2002) recently described a lab designed to measure vagal tone in human participants as a function of movement and stressors. Griffin found that the computer- based physiological recording systems allowed for efficient data collection and analysis, thus allowing more lab time for student discussion about the experiment and its conclusions, which facilitated student understanding of the laboratory experience.

Similar to other researchers who have used computer-based technology in their neuroscience classes (Lennartz, 1999; Tyler & Voneida, 1992), Evert, Goodwin, & Stavnezer (2005) believe that the use of computer technology enhanced the pedagogical value of their laboratory activities to students. Like Griffin (2002), they found that the computer-based physiological recording system allowed for efficient data collection and analysis, which allowed more time to discuss the experiments and their results.

The purpose of this study was to determine the learning styles of our nursing students and to investigate the relationship between these varied teaching styles on one hand, and both student satisfaction with different instructional methods and academic achievement. In this article, we report evidence of the major impact that iWorx is beginning to have on the teaching and learning in anatomy and physiology laboratories. Unlike a traditional lab that uses preset procedures to illustrate and coordinate closely with principles and lecture concepts, this lab is structured to develop students' abilities to do science as a physiologist does within a broad physiology framework. By using the technology, students are able to respond enthusiastically to the challenge of designing interesting experiments based on clear, testable hypotheses. Active scientific experiments model the excitement of performing physiological experiments and reinforce anatomical and physiological concepts from the lecture part of the course. In addition, these experiments develop skills in scientific communication through written reports. Finally, the iWorx technology facilitates learning through group collaboration and teamwork, and through students' application of technology for data collection, analysis, presentation, and literature research. Therefore, it provides students with higher motivation and increased comfort levels in clinical situations, and also increased quality of teaching, as reported in student satisfaction with learning that is enhanced with technology.

Since their direct exposure to the kinds of active technology and research processes presented in this study, the students have developed both critical thinking and reflective judgment of physiological concepts, as evidenced by self-reported assessments after completing lab reports. This study also demonstrates gains in student learning and knowledge in comparisons between iWorx users' and non-users' lab practical scores. In groups of students who took the survey with two different dominant learning styles, the lab practical scores were significantly higher for those students who used iWorx than for those who did not use iWorx.

III. METHODS

All experimental procedures were approved by the Institutional Review Board of the Nebraska Methodist College. Students who participated in this investigation were enrolled in fall 2012 and spring 2013 anatomy and physiology courses. We compared the lab practical scores from these students to the scores from previous students who had not been exposed to using iWorx. We introduced the unique features of experimentation with human subjects in 4 lab exercises: brain activities, skeletal muscles actions, cardiovascular function, and respiratory function. Near the end of each lab session, students used the iWorx 214 system to perform a laboratory exercise that integrated their knowledge into a true learning experience. For example, students studied heart rate variation over time as an illustration of negative feedback regulation and homeostasis. Students compared mean, median, and mode resting heart rates of the class and of male vs. female subjects. As instructors, we introduced spreadsheets for data collection, calculation, generation of presentation-quality tables, and performance of statistical tests.

Students recorded the data from a 3-lead ECG, EEG, EMG, and spirometer to examine the relationship among the results of various clinical systems. Students recorded the effects of exercise on pulse and ECG in subjects during the lab period, evaluated the alpha and beta waves on the EEG from having eyes open compared to having eyes closed, compared EMGs from dominant and non-dominant forearms, and measure lung volumes and lung capacities after recording effects of exercise on spirometer readings. Students continued to be successful at using the LabScribe software to analyze data, record data to the journal database for future comparison, and add functions to the analysis window for data collaboration.

Each lab session starts with the demonstration of models and slides relevant to each body system, and then moves to tissue dissection exercises. Finally, one student from each divided group is selected to be tested for the experiments; other team members perform and record the data by using iWorx.

During the remainder of the term, students examined the previously mentioned experimental systems, presented in multi-week modules. All the modules were based on the use of the iWorx 214, which provided computerized data recording and analysis using multiple transducers. Each multi-week module began with a presentation of the system or model, with background anatomical and physiological concepts, and with the techniques or methods used to test hypotheses related to that system. Students were then invited to experiment freely with the equipment to explore potential questions for further investigation. Using an experimental design protocol, research teams of 4 students then gathered to identify a question of interest, developed a specific, testable hypothesis, designed well-controlled experiments, determined what data would be collected, and predicted the ways in which the data would be managed and presented. The team chose a principal investigator (PI) for each experiment in turn; this PI was in charge of the experiment and consolidated the data. The group discussed the results, and completed the report together. The following week, before the lab session, the PI was required to submit the completed experimental design sheet and a draft of an introduction section for the lab report. This included a specific hypothesis and background references for the study, with at least three primary sources. The whole team received a grade based on the report.

The students also completed an attitude and knowledge survey, once before the activities and again after activities, providing self-ratings of their comfort level, knowledge or experience, and interest in 10 content and skill areas targeted by the laboratories. To ensure confidentiality, pre-post responses were matched by numeric codes (see Appendix A).depending on the number of figures and number of pages containing color

IV. ANALYSIS

The quantitative data was entered into SPSS version 19 for analysis. After the data were sorted and analyzed, the greatest and least differences were observed among the students within and between the questions. Statistical significance was assigned a P value of < 0.05. Anatomy and physiology students who were enrolled in AP I and AP II courses showed very similar results; thus, all student data were pooled for the entire analysis.

V. RESULTS

A. *Student Self-Perceptions*

On a 5-point scale ranging from 1 (very low) to 5 (very high), students' mean entry levels ('before') of 'Comfort level' on 10 laboratory-related skills ranged from 2.82 to 3.68 ($M = 3.20$). At the end of the lab practices ('after'), all the ratings ranged from 3.46 to 3.93 ($M = 3.68$) (see Table 1 of significance of increase from 'before' to 'after'). All 72 within-subjects comparisons (Fig. 1) yield significant paired-samples t tests indicating higher significance (all 2-tailed $p < 0.05$). The 'Comfort Level' of applying the scientific method to physiological issues, using computer-based laboratory equipment (iWorx), and knowledge of scientific methodologies increased with highest statistical significance (2--tailed $p < 0.001$).

On the same survey form, students' mean entry level ('before') of 'Knowledge or experience' on 10 laboratory-related skills ranged from 2.49 to 3.49 (M = 2.98). At the end of the lab practices ('after'), all the ratings average from 3.36 to 3.81 (M = 3.56) (see Table 1). Most of 72 within-subjects comparisons (Fig. 2) yield significant paired-samples t tests indicating highest significance (all 2-tailed $p < 0.005$). The only level that does not show a significant difference is the 'Knowledge or Experience' of learning fundamental principles, generalization, or theories of anatomy and physiology (2-tailed $p = 0.108$).

TABLE I
COMPARISON OF COMFORT LEVEL, KNOWLEDGE /EXPERIENCE AND INTEREST WITH/WITHOUT USING IWORX

Comfort Level: Before to After	SIGNIF.	Knowledge / Experience: Before to After	SIGNIF.	INTEREST: BEFORE TO AFTER	SIGNIF.
Question 1	0.000		0.000		0.008
Question 2	0.003		0.000		0.110
Question 3	0.018		0.000		0.266
Question 4	0.046		0.005		0.535
Question 5	0.030		0.108		0.935
Question 6	0.000		0.000		0.032
Question 7	0.001		0.000		0.010
Question 8	0.004		0.000		0.114
Question 9	0.003		0.000		0.152
Question 10	0.045		0.000		0.103

Margin of error= 0.025

Students' mean entry levels ('before') of 'Interest' on 10 laboratory-related skills ranged from 3.01 to 3.79 (M = 3.42). At the end of the lab practices ('after'), all the ratings average from 3.49 to 3.89 (M = 3.69) (Table 1). Most of 72 within-subjects comparisons (Fig. 3) do not yield significant paired-samples t tests indicating highest significance (all 2- tailed $p > 0.05$). The only level yielding a significant difference is student 'Interest' in applying the scientific method to physiological issues (2- tailed $p < 0.01$).

B. Relative Performance on Laboratory Practical Tests

Two course instructors, one of whom did not use iWorx, independently scored a total of 490 students on a scale of 100% on their performance on laboratory practical tests. From 2006 to 2012, 252 students within the survey group did not use the iWorx, and the other 252 students did use iWorx. The mean score of the group that did not use iWorx was 76.08%, and the mean score of the group that did use iWorx was 79.51%. The significance between two groups is illustrated in Fig. 4 (2-tailed $p < 0.01$).

VI. DISCUSSION

From traditional lecture and lab teaching to computer-based activities, technological advances have been applied in medical sciences education in an effort to enhance students' learning. As educators, we facilitate each student's journey toward independent learning in accordance with current standards in science pedagogy, but we must also help students to learn how to use technologies to seek, organize, analyze, and apply information appropriately.

Those who challenge the technological imperative do so from a variety of perspectives. Some (11, 12) think that technology weakens our ability to think rationally or logically. Others go further and suggest that the pressure to use technology is a conspiracy by multinational companies and big business to sell technology and to attract young people forever into being technology consumers.

Some supporters of the use of technology in teaching believe that there are important educational benefits in using technology for teaching, but recognize the pressure, especially on senior management, to be fashionable and to have the latest "toys," and they leverage that pressure to win support for their technology-based teaching initiatives. Content is, of course, an essential element in quality teaching. However, it is just as important with technology-based teaching to focus on the other quality issues of course and program planning, instructional design, and student support, as these issues will be new or different from those faced in conventional teaching. Thus we agree that the aim when using technology is not to be as good as traditional teaching, but better (1, 10, 15).

The use of iWorx in anatomy and physiology courses allows us to meet our pedagogical objective of learning to apply course material to improve thinking, problem solving and decisions. Students who use iWorx to perform simple activities such as ECG, EEG, EMG, and spirometry report likely increases in their own comfort levels (Fig.1; Table 1) with laboratory related skills, especially when applying the scientific method to physiological issues, using computer-based laboratory equipment, and learning new scientific methodologies. This hands-on learning and kinesthetic activities improve conceptual learning in cardiovascular, neurological, muscular, and respiratory physiology in the lectures (Fig 2, 4; Table 1). Similar to other researchers who have used computer-based technology in their classes, we find that the use of iWorx enhances the knowledge and experience of students' laboratory skills (Fig. 2). It also provides the students with opportunities for efficient data collection and analysis. This in turn leads students to discuss the experiments and their results with greater ease. Except for demonstrated increases in applying the scientific method to physiological issues, student interest levels do not increase at a statistically significant level immediately after the activities are put in place. This result indicates that there are limitations while integrating computer technology into the introductory-level anatomy and physiology laboratory (Fig. 3; Table 1). Also, the learning preference information was collected via self-reporting rather than by validated instruments, although the data were similar to other published data (Breckler, Joun, & Ngo, 2009). Because students had much interest before we started to use iWorx, the "interest" level was not shown an increase.

In summary, the lab activities were designed by using computer-based technology to give students hands-on learning experience and to teach them how to collect and interpret scientific data. The students reported that they understood the concepts more quickly and easily; the students also demonstrated better mastery of the course material, as reflected in improvements in students' lab performance when using iWorx.(Fig. 4).

VII. Limitations

Limitations of this study arise from the relatively small sample size. Because our results represent only two groups of student in one nursing school, they cannot be generalized to other populations. The factors that can affect student satisfaction and achievement, such as varied learning environments, individual characteristics of students and teaching staff, and changing facilities and equipment, differ from one semester to another. Longitudinal studies in larger groups would provide more generalizable results.

Appendix A

Questionnaire

Questionnaire Item	First Week	Second Week	Change
Applying the scientific method to physiological issues			
Comfort level			
Knowledge or experience			
Interest			
Learning to apply course material to improve problem solving and decision			
Comfort level			
Knowledge or experience			
Interest			
Developing specific skills, competencies and points of view needed by professionals in the field most closely related to this course			
Comfort level			
Knowledge or experience			
Interest			
Gaining factual knowledge of Anatomy and Physiology (terminology, classifications, trends)			
Comfort level			
Knowledge or experience			
Interest			
Learning fundamental principles, generalization, or theories of Anatomy and Physiology			
Comfort level			
Knowledge or experience			
Interest			
Using computer-based laboratory equipment (iWorx)			
Comfort level			
Knowledge or experience			
Interest			
Knowledge of scientific methodologies			
Comfort level			
Knowledge or experience			
Interest			
Drawing conclusions from a physiological study			
Comfort level			
Knowledge or experience			
Interest			
Knowledge of physiology as a scientific discipline			
Comfort level			
Knowledge or experience			
Interest			
Knowledge of clinical applications			
Comfort level			
Knowledge or experience			
Interest			
Do you have any comments you would like to share about iWorx?			

Note: Scale is from 1 (very low) to 5 (very high).

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References

[1] Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in the technology-using classroom? Computer Education, 39, 395-414. doi:10.1016/S0360-1315(02)00075-1

[2] Bradshaw, G. L., Steinman, B., & McCarley, N. (2002). ePsych: Interactive demonstrations and experiments in psychology. Behavioral Research Methods, Instruction, and Computing, 34, 231-133. doi:10.3758/BF03195448

[3] Breckler, J., Joun, D., & Ngo, H. (2009). Learning styles of physiology students interested in the health professions. Advances in Physiology Education, 33, 30-36. doi:10.1152/advan.90118.2008

[4] Cohen, S. A. (1987). Instructional alignment: Searching for a magic bullet. Educational Research, 16, 16-20. doi:10.2307/1175370

[5] Evert, D. I, Goodwin, G., & Stavnezer, A. J. (2005). Integration of computer technology into an introductory-level neuroscience laboratory. Teaching Psychology, 32, 69-73. doi:10.1207/s15328023top3201_14

[6] Griffin, J. D. (2002). Technology in the teaching of neuroscience: Enhanced student learning. Advances in Physiology Education, 27, 146-155. doi:10.1152/advan.00059.2002

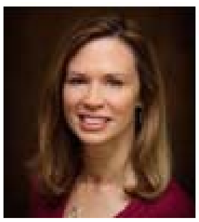
[7] Lennartz, R. C. (1999). Electrophysiology of the undergraduate neuroscience student: A laboratory exercise in human electromyography. Adv Physiol Educ 22: S42-S50.

[8] Solomon, P. R, Cooper S., & Pomerleau, D. (1988). Computer simulation of the neuronal action potential. Teaching Psychology 15, 46-47. doi:10.1207/s15328023top1501_14

[9] Thomas, R. R, & George, K. (2003). Testing the relationship between levels of endogenous testosterone and physiological responses to facial expressions in men: An experiment conducted by students in an undergraduate behavioral neuroscience class. Journal of Undergraduate Neuroscience Education, 1, A41-47.

[10] Tyler, T.J, & Voneida, T. J. (1992). Use of computer-assisted courseware in teaching neuroscience: The graphic brain. American Journal of Physiology, 263, S37-44.. O. Young, "Synthetic structure of industrial plastics (Book style with paper title and editor)," in *Plastics*, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.

Dr. Feng Feng is an Assistant Professor at Nebraska Methodist College, Omaha, NE, USA. After graduating from medical college, Dr. Feng practiced cardiology for six years in China, and then reentered in the graduate school studying sports Medicine. She also holds M.S. in Sports Medicine. From 2002 to 2007, she completed her post-doctoral training at Creighton University. Dr. Feng has published over 30 papers including invited contributions to international journals and conferences. Dr. Feng is a member of the Human Anatomy and Physiology Society. She has been awarded a Faculty Grant from Human anatomy and Physiology Society in 2012.



Dr. April Horstman Reser is an Assistant Professor in the Division of Arts and Sciences at Nebraska Methodist College. Dr. Horstman Reser's graduate degree is research-based with a Graduate Major in Social Psychology and a Graduate Minor is in Quantitative Psychology. Dr Horstman Reser has taught at the University of Kansas, the Massachusetts College of Liberal Arts, and at NMC. She is the Institutional Review Board Chair (IRB) and assists faculty and students with research and statistical projects.

Dr. Lusby has been at Nebraska Methodist College since January of 1995. She has taught Human Anatomy and Physiology I and II, Human Anatomy and Physiology for Allied Heath students, Pathophysiology /Pharmacology for Allied Heath students, Introduction to Pharmacology and also Pathophysiology. Her passion is to help her students make use of what they learn in her courses to apply to new healthcare situations. She moved into her administrative position in 2004.

Table 1: Comparison of comfort level, knowledge /experience and interest with/without using iWorx

Comfort Level: Before to After	Signif.	Knowledge/Experience: Before to After	Signif.	Interest: Before to After	Signif.
Question 1	0.000	Question 1	0.000	Question 1	0.008
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Question 7	0.001	Question 7	0.000	Question 7	0.010
Question 8	0.004	Question 8	0.000	Question 8	0.114
Question 9	0.003	Question 9	0.000	Question 9	0.152
Question 10	0.045	Question 10	0.000	Question 10	0.103

Fig 1: Comparison ‘comfort level’ before and after using iWorx

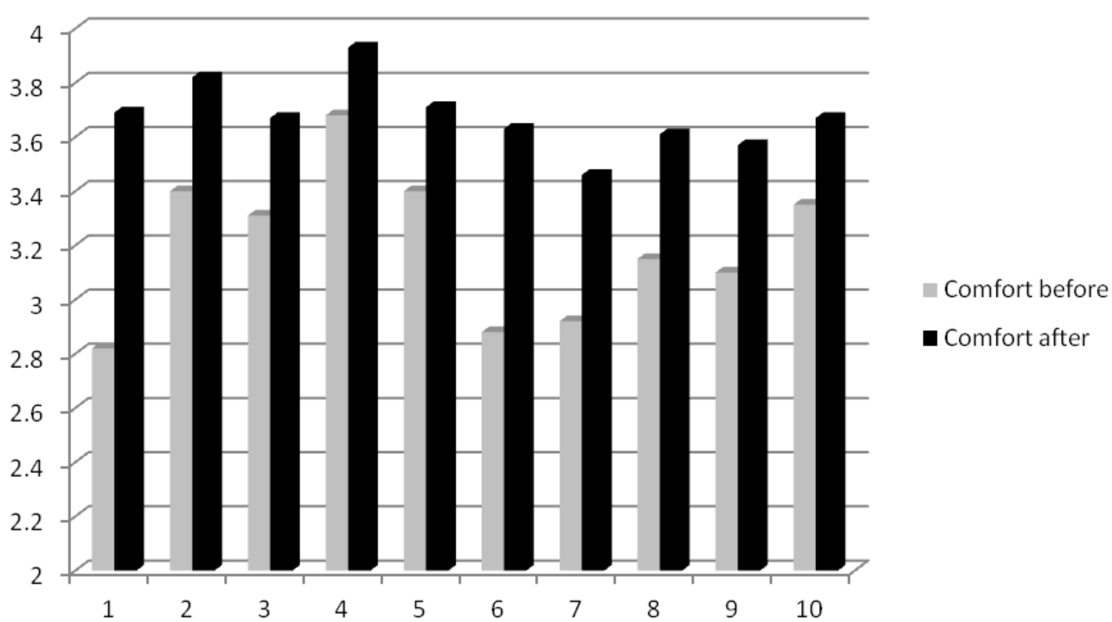

Fig 2: Comparison of 'knowledge and experience' before and after using iWorx

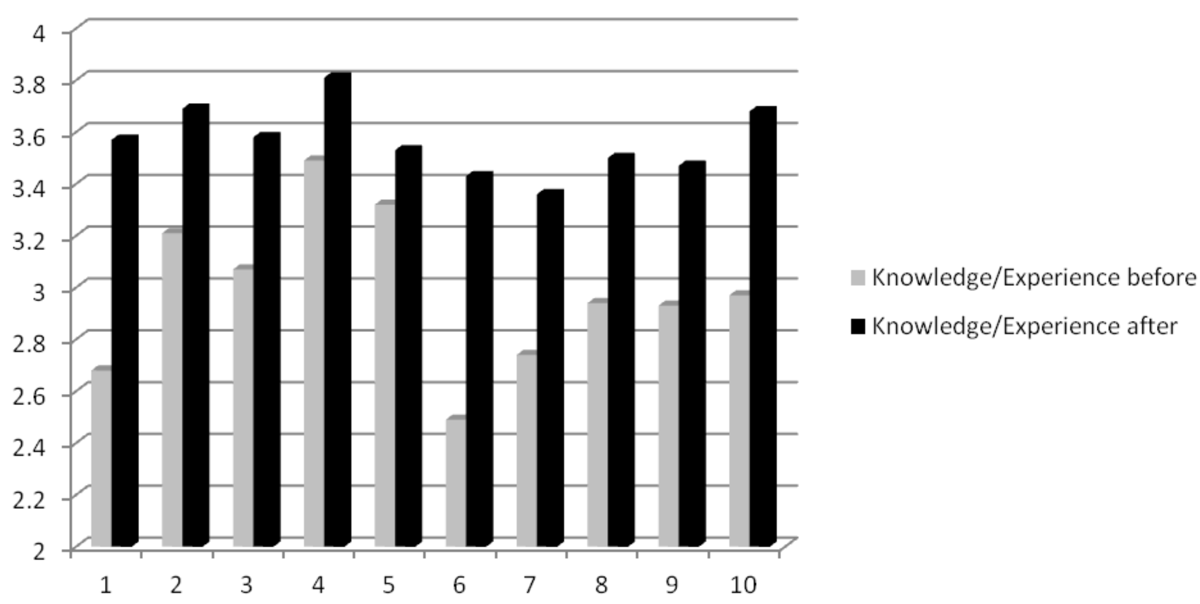

Fig 3: Comparison of 'interest' levels before and after using iWorx

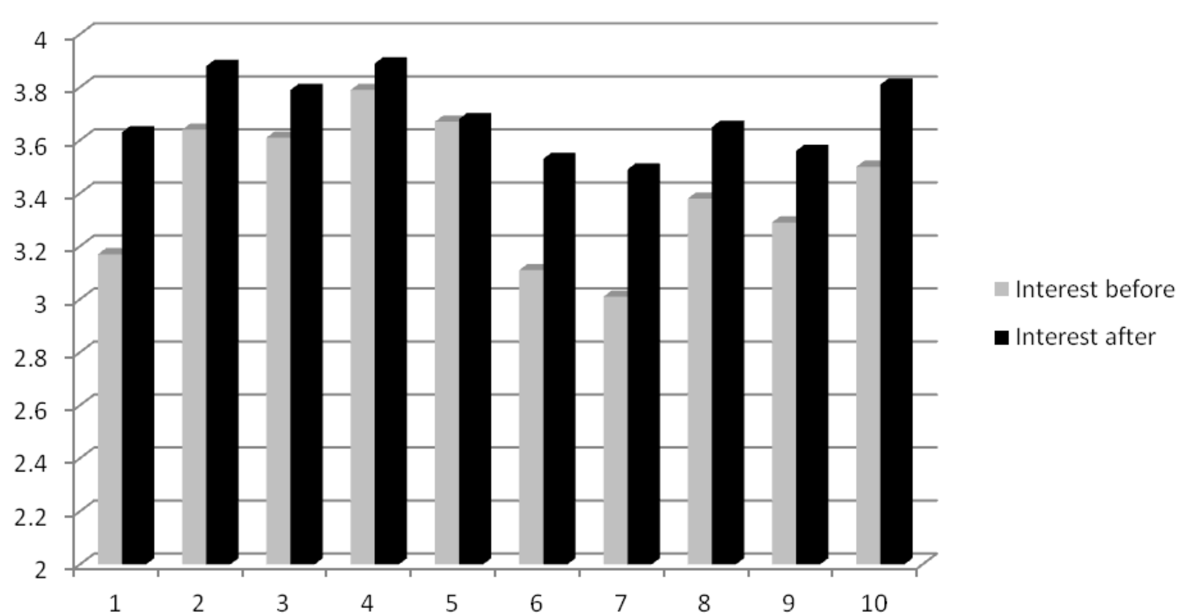

Fig 4: Student performance with/without using iWorx