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Effects of web-based electrocardiography simulation on strategies and learning styles

Efeitos da simulação eletrocardiográfica em ambiente web sobre as estratégias e estilos de aprendizagem

Efectos de la simulación electrocardiográfica en ambiente web acerca de las estrategias y estilos de aprendizaje

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ABSTRACT

Objective: To identify the association between the use of web simulation electrocardiography and the learning approaches, strategies and styles of nursing degree students. **Method:** A descriptive and correlational design with a one-group pretest–posttest measurement was used. The study sample included 246 students in a Basic and Advanced Cardiac Life Support nursing class of nursing degree. **Results:** No significant differences between genders were found in any dimension of learning styles and approaches to learning. After the introduction of web simulation electrocardiography, significant differences were found in some item scores of learning styles: theorist ($p < 0.040$), pragmatic ($p < 0.010$) and approaches to learning. **Conclusion:** The use of a web electrocardiogram (ECG) simulation is associated with the development of active and reflexive learning styles, improving motivation and a deep approach in nursing students.

DESCRIPTORS

Simulation; Electrocardiography; Internet; Computer-Assisted Instruction; Education, Nursing; Learning.

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INTRODUCTION

Traditionally, the electrocardiogram (ECG) has aided the diagnosis, treatment and monitoring of arrhythmias, coronary syndromes and cardiac revascularization[1]. These pathologies, often found in pre-hospital, accident and emergency and critical care settings, pose a life-threatening risk that requires quick diagnosis and treatment. ECG monitoring and interpretation skills are gained in medical education and strengthened by experience. However, the need for immediate pattern recognition and subsequent procedures involves nurses in the processes of evaluation, registration, and initiation of reperfusion therapies as well as in the detection of complications and the request for assistance.

ECG interpretation requires high-order learning. Although the ECG has historically been taught in a traditional classroom, new methodologies have changed the teaching-learning process in response to the lack of time and resources. Health science educators should focus their teaching methods on the student, developing new learning processes and adapting their strategies to each context or discipline. In academic nursing education, this new status quo favors technology, motivation, active participation and simulation[2-3]. Multiple technologies have been applied to ECG teaching in medicine, nursing and pharmacy degrees for both undergraduates and postgraduates, including a multimedia CD-ROM, videograms, computer programs, computer-assisted tutorials, multimedia teaching and interdisciplinary approaches[1,4]. Human simulation, web-based video and web simulation tools[5] have been used to develop ECG diagnostic skills in advanced cardiac life support (ACLS).

The ECG diagnostic skills are not optimal, and training programs are not homogeneous in terms of time and methodologies. Students who received training in a lecture-workshop showed better results in ECG interpretation than those who followed self-directed learning[6]; peer tutoring has proved to be more efficient than traditional classes. However, both the lack of conclusive results and the economic costs have led to the increase in the use of web simulation in the fields of medicine and nursing[7-8].

Web-based learning promotes computer-mediated interaction and student-centered learning in most higher education institutions[9]. Some health science curricula include web simulation, which is widely accepted due to its easy, flexible and independent access, reinforcing individual self-study through training[10]. Students have acknowledged web ECG interpretation as a useful tool, with better immediacy, visualization and interaction than traditional teaching methods. Practical and professional training for nurses is based on acquiring skills, abilities and knowledge; various methodologies have been employed to teach ECG to nurses[11]. Interactive web-based learning has been successful in critical care and cardiac monitoring units[12], where in addition to preparing the skin or placing the electrodes correctly, potentially fatal arrhythmias must be identified.

The use of simulation in ECG courses has been shown to have advantages in the classroom, improving self-confidence and critical thinking. Web simulation and personalized training show good results in ACLS; their efficiency in arrhythmia interpretation should be extended to the entire ECG[13]. However, these techniques may not suit all learners and are therefore critiqued based on the identified limitations[14]. Furthermore, we need to discover their effects on nurses' knowledge, skills, satisfaction and learning styles[15]. Strategies and learning styles are related to personal variables which explain ways of receiving, processing and retaining information; understanding these processes helps create an efficient learning atmosphere[16]. Additionally, learning styles and strategies can be modified by the methodology used (for example, by using web simulation). Although the ECG simulator may be useful in gaining and maintaining basic ECG interpretation skills, empirical research is needed to analyze its association with learning approaches, strategies and styles of nursing degree students.

The six-second ECG (SS-ECG) is a free web simulator that generates and allows for the learning of twenty-seven common cardiac rhythms[17]. Using the "explore-review" function and clicking on any rhythm name, the software displays the rhythm and its description. Using the "explore-review-play" function allows for the diagnosis of the ECG after setting the game time period, dynamic or static rhythm display, sound volume and grid display.

The purpose of this descriptive and correlational study was to describe the relationship between the use of a web-simulator (SS-ECG) and the learning approaches, strategies and styles of nursing degree students.

METHOD

Design and Sample

A descriptive and correlational design, in conjunction with a one-group pretest–posttest method, comprised our research design. During 2012 and 2013, all the students who were matriculated in the ACLS course, which is part of the nursing degree curricula at the University of Almeria (Spain), were invited to participate in the study. Of the 258 students enrolled in the course, 246 students of both sexes participated in the study, 125 in 2012 and 121 in 2013.

Instruments

Two standardized tests were used, both of which had been empirically validated in the Spanish language. To assess learning styles, we used the *Cuestionario Honey-Alonso de Estilos de Aprendizaje* (CHAEA) (Honey-Alonso Learning Styles Questionnaire)[18]. The CHAEA consists of 80 items with a dichotomous reply, 20 items per style, which structures 4 learning styles according to individual preferences relating to accessing knowledge. Active style, based on direct experience, prevails in the inquisitive, resourceful and spontaneous student. Reflexive style, based on observation, is found in receptive, analytical and patient students. Theorist style, based on conceptualization, is strongest in methodical, objective and critically minded students. Pragmatic style, based on experience, is typical in practical, direct and realistic students.

To evaluate learning approaches, strategies and motivations adopted by students, the *Cuestionario de Evaluación del Proceso de Enseñanza-Aprendizaje* (CEPEA) (Evaluation of Learning and Study Processes Questionnaire)[19], a Spanish adaptation of the Biggs Study Process Questionnaire (SPQ), was used. The CEPEA consists of 42 items, 21 related to motivation and 21 related to strategies, using a Likert-style scale (1-5). At the first level, these categories provide the scores for 6 sub-scales, 3 for motivation and 3 for learning strategies: Surface Motivation (SM), Deep Motivation (DM), High Performance Motivation (HPM), Surface Strategy (SS), Deep Strategy (SD) and High Performance Strategy (HPS). At the second level, the scores for 3 learning approach scales, which integrate motivations and strategies, are obtained: Surface Approach (SS+SM), Deep Approach (DS+DM) and High Performance Approach (HPS+HPM).

Procedures

During the week prior to the intervention and after signing the informed consent form to participate in the study, the participants completed the CHAEA and CEPEA (pre-test) questionnaires. A 3-hour educational intervention using the SS-ECG simulator was conducted with groups of 15 students in two in-person stages. In the first stage (2-hour simulation exercise in a group using the SS-ECG simulator function '*PREPARED*'), the teacher randomly projected one of the 27 rhythms to the entire class, concealing the diagnosis. Each student, who was randomly chosen, analyzed and diagnosed two ECG rhythms systematically, responding to the following questions: name of the rhythm; presence of atrial contraction (yes/no); sufficient ventricular filling time (yes/no); effect on cardiac oxygen supply/demand; cardiac output (sufficient/reduced) and gravity of rhythm. The rest of the students listened, although the teacher could ask them a question at any moment. The solution was then shown, the mistakes were analyzed and any questions were answered. In the second stage (1-hour individual-based simulation exercise using the SS-ECG function *'PLAY'*), each student analyzed and diagnosed random ECG rhythms on their PC using the following pattern: 2 repetitions of 6 minutes, 4 repetitions of 4 minutes, 6 repetitions of 2 minutes, and 8 repetitions of 1 minute, resting for 3 minutes between each group of attempts. Post-intervention data were collected the following day, with each student completing the CHAEA and CEPEA questionnaires.

Ethical Considerations.

The study was approved by the ethical and research committee of the Department of Nursing, Physiotherapy and Medicine at the University of Almeria (Protocol number: 6/2012). In accordance with the Helsinki Declaration, informed consent was obtained from the students.

Data Analysis

SPSS version 18.0 was used for the analyses. The reliability and validity of the model hypothesis were studied by analyzing the residual independence, normal distribution and homogeneity of variances. The Kolmogorov-Smirnoff test was used to analyze the normal distribution of variables. Descriptive statistics were obtained by measuring the central tendencies and rate of dispersion in the variables studied. An imputed score was calculated for standardized scales missing ≤ 10% of responses. Student's *t*-test was used to examine the differences between baseline and after intervention with simulation SS-ECG. We used Pearson´s correlation coefficient (r) with a 95% confidence interval for linear correlations between variables. A P-value < 0.05 was considered significant in all tests.

RESULTS

The study sample included 246 students enrolled in an ACLS course as part of a nursing degree program during the academic years 2012/2013 and 2013/2014. The response rate was 95.34% (of the 12 students not included in the study, 5 declined to participate, and 7 only completed the pre-test). The distribution of the sample and descriptive statistics for each dimension in learning styles and approaches to learning are shown in Table 1.

Table 1 – Descriptive characteristic of the sample (n = 246) – Almeria, Spain – 2014.

Variable	Women		Men	
Gender [n (%)]	189 (76.83%)		57 (23.17%)	
Age (M±SD)	22.03 ± 5.06		23.54 ± 6.08	
	Baseline (M±SD)	**Post-intervention (M±SD)**	**Baseline (M±SD)**	**Post-intervention (M±SD)**
Active	10.70 ± 3.76	11.00 ± 3.72	10.38 ± 3.72	10.15 ± 3.82
Reflexive	14.29 ± 3.34	14.77 ± 3.56	14.94 ± 4.00	14.63 ± 4.44
Theorist	12.21 ± 3.02	12.86 ± 2.76	12.17 ± 3.54	12.42 ± 4.09
Pragmatic	11.67 ± 3.32	12.23 ± 3.59	11.77 ± 3.64	12.17 ± 3.86
Surface Strategy	20.20 ± 3.35	20.61 ± 3.64	20.59 ± 3.05	20.68 ± 3.63
Surface Motivation	24.24 ± 4.48	23.60 ± 4.07	24.07 ± 3.05	23.49 ± 4.50
SS + SM	44.49 ± 6.44	44.12 ± 6.36	44.66 ± 6.24	43.80 ± 7.22
Deep Strategy	23.68 ± 3.59	23.03 ± 4.02	23.15 ± 4.12	22.17 ± 4.76

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Variable	Women		Men	
Gender [n (%)]	189 (76.83%)		57 (23.17%)	
Age (M±SD)	22.03 ± 5.06		23.54 ± 6.08	
	Baseline (M±SD)	**Post-intervention (M±SD)**	**Baseline (M±SD)**	**Post-intervention (M±SD)**
Deep Motivation	23.94 ± 3.70	23.72 ± 4.20	24.22 ± 4.33	23.08 ± 4.41
DS + DM	47.35 ± 7.04	46.44 ± 8.00	47.01 ± 8.22	45.15 ± 8.34
High Performance Strategy	23.12 ± 4.29	22.52 ± 4.01	22.26 ± 4.30	21.45 ± 4.27
High Performance Motivation	20.37 ± 4.64	20.14 ± 4.82	21.12 ± 4.90	20.14 ± 4.75
High Performance Approach (HPS + HPM)	43.39 ± 7.44	42.57 ± 7.21	43.38 ± 8.05	41.24 ± 7.92

Values are presented as the mean and standard deviation (M ± SD). Abbreviations: SS (Surface Strategy), SM (Surface Motivation), DS (Deep Strategy), DM (Deep Motivation), HPS (High Performance Strategy), and HPM (High Performance Motivation).

Mean differences were tested considering gender (*t*-test). No significant differences between genders were found in any dimension of learning styles and approaches to learning. After the introduction of SS-ECG simulation, significant differences were found in some item scores of learning styles: theorist ($p < 0.040$), and pragmatic ($p < 0.010$). Table 2 shows baseline, post-intervention, and within-group differences with associated 95% confidence intervals (CI) for learning styles dimensions.

Table 2 – Baseline, post-intervention and change score for learning style dimensions – Almeria, Spain – 2014.

Variable	Mean ± Standard Deviation		Within-group Score Change	P-value
Active	Baseline	10.62 ± 3.74	-0.19 (-0.76, 0.36)	0.493
	Post-intervention	10.79 ± 3.75		
Reflexive	Baseline	14.45 ± 3.50	-0.41 (-0.97, 0.13)	0.138
	Post-intervention	14.71 ± 3.78		
Theorist	Baseline	12.20 ± 3.14	-0.53 (-0.90, -0.17)	0.004*
	Post-intervention	12.73 ± 3.13		
Pragmatic	Baseline	11.67 ± 3.41	-0.53 (-0.94, -0.13)	0.010*
	Post-intervention	12.21 ± 3.64		

(*P-value < 0.05)

Additionally, there were significant differences in some items of approaches to learning: surface motivation ($p < 0.001$), deep strategy ($p < 0.002$), deep approach ($p < 0.020$), high performance strategy ($p < 0.006$), and high performance approach ($p < 0.013$). Table 3 shows baseline, post-intervention, and within-group differences with associated 95% confidence intervals (CI) for approaches to learning dimensions.

Table 3 – Baseline, post-intervention and change score for approaches to learning dimensions – Almeria, Spain – 2014.

Variable	Mean ± Standard Deviation		Within-group Score Change	P-value
Surface Strategy	Baseline	20.31 ± 3.29	-0.33 (-0.80, 0.13)	0.160
	Post-intervention	20.65 ± 3.64		
Surface Motivation	Baseline	24.23 ± 4.43	-19.86 (-20.61, -19.11)	0.001*
	Post-intervention	23.60 ± 4.17		
SS + SM	Baseline	44.58 ± 6.42	0.48 (-0.30, 1.28)	0.225
	Post-intervention	44.09 ± 6.58		
Deep Strategy	Baseline	23.57 ± 6.4	0.73 (0.28, 1.18)	0.002*
	Post-intervention	22.84 ± 4.20		
Deep Motivation	Baseline	24.04 ± 3.91	0.44 (-0.48, 0.93)	0.077
	Post-intervention	23.60 ± 4.26		
DS+ DM	Baseline	47.33 ± 7.35	1.15 (0.18, 2.12)	0.020*
	Post-intervention	46.17 ± 8.08		
High Performance Strategy	Baseline	22.92 ± 4.29	0.65 (0.19, 1.11)	0.006*
	Post-intervention	22.26 ± 4.08		

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Variable	Mean ± Standard Deviation		Within-group Score Change	P-value
High Performance Motivation	Baseline	20.55 ± 4.71	0.38 (-0.18, 0.95)	0.186
	Post-intervention	20.17 ± 4.77		
High Performance Approach (HPS+HPM)	Baseline	43.40 ± 7.56	1.11 (0.23, 1.98)	0.013*
	Post-intervention	42.28 ± 7.41		

*P-value < 0.05. Abbreviations: SS (Surface Strategy), SM (Surface Motivation), DS (Deep Strategy), DM (Deep Motivation), HPS (High Performance Strategy), and HPM (High Performance Motivation).

At baseline, according to Pearson´s linear correlation analysis, there was no correlation between active learning styles and approaches to learning dimensions. However, significant inverse correlations (P < 0.05) were found between reflexive, theorist and pragmatic learning styles and all learning approach dimensions. After the intervention using the SS-ECG simulator, positive and inverse correlations were found between some dimensions of learning styles and approaches to learning. An inverse association was found between an active learning style and surface strategy (r > -0.137, p < 0.031) and surface approach (r > -0.131, p < 0.040). The reflexive learning style showed linear positive correlations with deep motivation (r > 0.223, p < 0.001), deep approach (r > 0.170, p < 0.008), high performance strategy (r > 0.164, p < 0.010), high performance motivation (r > 0.131, p < 0.040), and high performance approach (r > 0.193, p < 0.002). Theorist learning styles had linear inverse associations with deep strategy (r > -0.245, p < 0.001), deep motivation (r > -0.236, p < 0.001), deep approach (r > -0.256, p < 0.001), high performance strategy (r > -0.325, p < 0.001), high performance motivation (r > -0.266, p < 0.001), and high performance approach (r > -0.349, p < 0.001). Additionally, an inverse linear correlation was found between pragmatic learning styles and surface motivation (r > -0.166, p < 0.009), surface approach (r > -0.172, p < 0.007), high performance strategy (r > -0.130, p < 0.042), high performance motivation (r > -0204, p < 0.001), and high performance approach (r > -0.196, p < 0.002).

DISCUSSION

It is important that educators understand their students' learning styles, and determining the mean values for the scores in each style helps to create an overall learning profile of the sample[18]. The results show a variety of learning styles, in which the reflexive learning style dominates, followed by theorist, pragmatic and active styles. Our post-intervention results indicate a significant increase in theorist and pragmatic learning style scores, with no significant differences in gender and age.

The diverse nature of the students' preferences reinforces the need for various teaching strategies[20]. Learning involves cognitive processes that include motivation, strategies, attitude, information processing, use of support/material and approaches to achieve goals[9]. Understanding their relationship with learning styles could help with methodological innovations[21] and the creation of more efficient learning environments[20]. Simulation increases nurses' understanding and skills, improving self-confidence in ACLS. According to several studies, these procedures in the short term could improve nursing students' ECG interpretation abilities, increasing the chances of a successful diagnosis and the retention of knowledge[13].

Following the use of the SS-ECG, increased scores were found in the theorist and pragmatic dimensions of learning styles. This strengthening of the logical, objective and methodical components of the learning process may signal an improvement in the students' perception of the theory-practice relationship. The significant differences in the deep approach and High Performance Approach scores could be due to the lack of improvements in relation to previous knowledge or the planning of activities focused on achievements. Consistent with the post-intervention results, we found a significant relationship between learning strategies and styles[22]. The inverse association between active style and the development of surface strategies could indicate that spontaneous and resourceful students distance themselves from mechanical learning and repetitive information, and therefore, the interactivity with the simulators could prove to be useful and satisfying[15]. Students who adopt a deep approach to learning, with brighter prospects of success, are considered to be ideal for active methodologies. Following the procedure, we found a positive correlation between motivation-deep approach and the reflexive learning style, typical of students who are interested in working autonomously to obtain maximum performance and results. This relationship is inverted in the theorist style, as we see that the attitudes towards Simulation-Based Learning are not uniform[23]. Students with a pragmatic style who are interested in the application of content inversely correlate with those students who, using a motivation and surface strategy, aim to learn by memory.

The ECG facilitates nursing care in cases of acute coronary syndrome, with evidence showing the benefits of correct interpretation and monitoring of the ECG on the patient's safety. Cardiac patients believe that nurses need more solid ECG and arrhythmia training[24], and the simulation could help undergraduate students acquire these skills. Some studies have found improvements in ECG knowledge after multimedia activities[2], the use of Blackboard©, WebCT© or Moodle© environments, or the incorporation of self-learning[25]. The clinical nurses' motivations toward Web-based learning were predicted by their self-efficacy in terms of the Internet, in which nurses with higher Internet self-efficacy tended to display higher motivations for Web-based continued learning[26].

Instructional methods that actively engage learners improve learning outcomes; however, evidence regarding the use of web simulators as a learning methodology and its efficacy in practice is lacking[12]. Deciding to use web simulators is not related to learning styles but with the evaluation format used[10].

Accommodating learning styles in a Web-based educational system benefits the learning process, and teaching students using Web-based resources can provide engaging and timely content[27- 28]. Using the SS-ECG simulator is a successful example of the melding of technology and education to enhance clinical learning using learner-centered activities. Whereas some studies indicate the use of traditional methods to improve satisfaction or to retain knowledge and skills[2], the web simulation has been shown to be useful for teachers and students[29]. Teachers would have to consider learning approaches, styles, and strategies; therefore, it may be advisable to develop students' learning processes in the face-to-face context without technology before engaging them in technology-supported learning[30].

Limitations

Based on the cross-sectional design, the results of the intervention may be different in the same students in previous courses or in similar interventions.

CONCLUSION

The study results showed a variety of nursing students' learning approaches, strategies and styles. The use of the SS-ECG web simulator inversely correlates with the development of active and reflexive learning styles and surface motivation. Conversely, a positive correlation between the use of the SS-ECG web simulator and the development of a deep strategy, deep approach, high performance strategy and high performance approach was found. This knowledge is useful in adapting teaching strategies to the students' learning style in nursing curricula as a means of improving the education quality. Prior to the inclusion of new web simulation methodologies in the classroom, it may be important to respond to these considerations to benefit the teaching-learning process among nursing students.

RESUMO

Objetivo: Identificar associações entre o uso da simulação eletrocardiográfica na internet e os estilos e estratégias de aprendizagem dos estudantes de graduação em enfermagem. **Método:** Desenho descritivo-correlacional com avaliação pré e pós-teste num único grupo. A amostra do estudo incluiu 246 estudantes que frequentavam a disciplina de Suporte Básico e Avançado de Vida. **Resultados:** Não foram encontradas diferenças significativas entre gêneros em qualquer das dimensões dos estilos e estratégias de aprendizagem. Após introdução da simulação eletrocardiográfica recorrendo à internet, encontraram-se diferenças estatisticamente significativas em algumas das pontuações dos itens dos estilos de aprendizagem teórico (p <0,040), pragmático (p <0,010) e das estratégias de aprendizagem. **Conclusão:** O uso da simulação eletrocardiográfica em ambiente web está associado ao desenvolvimento de estilos de aprendizagem ativos e reflexivos, à melhoria da motivação e da abordagem profunda em estudantes de enfermagem.

DESCRITORES

Simulação; Eletrocardiografia; Internet; Instrução por Computador; Educação em Enfermagem; Aprendizagem.

RESUMEN

Objetivo: Identificar asociaciones entre el uso de la simulación electrocardiográfica en la internet y los estilos y estrategias de aprendizaje de los estudiantes de graduación en enfermería. **Método:** Diseño descriptivo-correlacional con evaluación pré y post prueba en un solo grupo. La muestra del estudio incluyó a 246 estudiantes que acudían a la asignatura de Soporte Básico y Avanzado de Vida. **Resultados:** No fueron encontradas diferencias significativas entre géneros en cualquiera de las dimensiones de los estilos y estrategias de aprendizaje. Después de la introducción de la simulación electrocardiográfica recurriendo a la web, fueron encontradas diferencias estadísticamente significativas en algunas de las puntuaciones de los ítems de los estilos de aprendizaje teórico (p <0,040), pragmático (p <0,010) y las estrategias de aprendizaje. **Conclusión:** El uso de la simulación electrocardiográfica en ambiente web está asociado con el desarrollo de estilos de aprendizaje activos y reflexivos, la mejoría de la motivación y el abordaje profundo en estudiantes de enfermería.

DESCRIPTORES

Simulación; Electrocardiografía; Internet; Instrucción por Computador; Educación en Enfermería; Aprendizaje.

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