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Biomechanics for first year occupational therapy students: enriching learning using an E-learning resource

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ABSTRACT

Introduction: *The educational requirements of students are constantly changing due to technological development. Technology can stimulate and enrich learning but ensuring that teaching methods remain relevant is a challenge. Hybrid learning, including e-learning, in occupational therapy is developing but remains a largely unexplored field in South Africa.*

Method: *Changes in achievement associated with the use of an e-learning resource developed for biomechanics was determined. Outcomes were measured using a quasi-experimental design with a pre-test-intervention-post-test repeated measure timeline method. Students' experiences associated with using this e-learning resource were determined by a survey questionnaire. A convenience sample group of N=81 first year occupational therapy students in 2010 and 2011 was obtained.*

Findings: *A positive change in achievement were identified especially at the lower levels of Bloom's taxonomy. The use of the e-learning resource was found to be a positive learning experience.*

Conclusion: *The e-learning tool had a significant effect on learning and the majority of participants experienced it as positive.*

Key words: electronic media-based learning (e-learning); performance; occupational therapy students; hybrid learning

INTRODUCTION

Rapid technological development and the expectations of students born during the era identified as the y-generation (1979-1995) has impacted on learning requirements. This generation relies on instant, easy access to information. They piece together information from multiple sources which strengthens their intuitive visual communication, this poses a unique challenge to educators today[1]. Even though face-to-face teaching is still required books are gradually being replaced by electronic media. Internet information is readily available and accessed by students but is not always controlled for accuracy, which may lead to confusion. To avoid this confusion, e-learning tools have been developed and included in structured educational institutions worldwide[2,3].

Educators are ultimately responsible for including e-learning resources in a manner that will improve rather than limit learning. Hybrid learning developed from the need to use electronic media to enhance education.

Internationally, occupational therapy educators have questioned the use of e-learning and whether it will be effective and acceptable to students. Initial resistance to e-learning in occupational therapy was identified possibly due to limited computer literacy[4,5,6]. Limited computer literacy was found in older studies where populations did not have daily access to computers. Most South African occupational therapy students now have access to electronic media and mobile devices, but many experience financial constraints which impact on their ability to own their own computer and pay for internet data. By 2011 when this study was conducted only 39% of urban and 27% of rural young people had mobile data access to the internet in South Africa[7]. Students thus did not have uniform access to mobile data resulting in different levels of computer literacy. Studies conducted by Ernst and Colthorpe[5], Ruiz et al[6] and Davies et al[8] between 2005 and 2007 found that e-learning lightens the lecturing burden because students may set their own goals and have more control over the content and the pace of learning. These findings and the need to accommodate the Y generation student's need to access information via electronic media served as the motivation to develop an e-learning tool for teaching and learning Biomechanics.

Occupational therapy students need to apply anatomical and mechanical knowledge when they assess and treat clients. Personal experience has shown that many occupational therapy students struggle to understand the mechanical principles applied to human function. Therefor an e-learning resource, in the form of an interactive CD, was developed as part of a hybrid learning[3] programme at the Occupational Therapy Department at the University of Pretoria, by the main author with the assistance of the Education Innovation Department. The 'Basic Biomechanics for therapists' CD[9] resource is based on the outcomes required for Biomechanics in occupational therapy. The question was asked whether South African occupational therapy students would benefit and be comfortable with using this e-learning resource.

LITERATURE REVIEW

E-learning resources are becoming more widely used in structured educational institutions worldwide. Rapid technological advances and the present generation of students place demands on educational developments[1]. The impact and implementation of e-learning is relevant in different disciplines[10,11]. Theoretically, the self-directed nature of e-learning may improve critical thinking[11].

Education in developing countries, such as South Africa, may be affected by the socio-economic level of communities. Children growing up in low-income households are often undernourished and more prone to illness which can result in absence from school[12]. It has been found that poor achievement in schools in low income areas may also stem from a lack of sufficiently trained teachers, who are attracted to more affluent schools[12]. People living in poor rural areas are also often excluded from participation in socio-political activities[13]. This exclusion may limit their involvement in decision-making, reducing educational opportunities and resources in their own environments[8]. In comparison, poor urban areas may have better infrastructure and technological resources. Varied exposure

to resources and educational opportunities could result in varied electronic-media competencies[8,12]. Unskilled students may be reluctant to use e-learning resources which may limit rather than assist learning. However, the use of e-learning may assist these students that may be perceived as slow learners to master the concepts in their own time by setting their own goals and learning at their own pace[5,6,8].

Attitudes of occupational therapy students to the use of electronic media have gradually changed over time. In 1998, Cameron[14] identified resistance to using computer-based learning with Y-generation students in Australasia. These students came from diverse cultural and socio-economic backgrounds in rural and urban areas and many of them had limited exposure to electronic media. In 2005, occupational therapy students in Birmingham (UK) indicated that e-learning was effective but that the use of computer-based tests (CBTs) caused extra strain[8]. Students' anxiety was associated with a lack of confidence in their computer literacy skills[7,14]. In 2007, medical students who were able to set their own goals, through e-learning, were more motivated to learn[5]. In 2014, South African occupational therapy students were still hesitant to use computer based learning, possibly due to computer illiteracy[4]. Despite increased availability and exposure to electronic media, the above findings confirm that e –learning programmes need to consider students' social and cultural backgrounds and previous exposure to electronic media[13, 14].

The cultural diversity of South African students necessitates evaluations of e-learning resources. The evaluation discussed in this paper considered the academic performance and experiences of first year occupational therapy students at a South African university.

METHODOLOGY

The biomechanics module taught to first year occupational therapy students at the University of Pretoria uses sequential learning. The module comprises two sections namely basic mechanics and the human body. These sections formed two study units each, the first being factual knowledge and the second application. The knowledge covered in each of these four learning units was built on knowledge gained from the preceeding unit, resulting in increased complexity. The material covered in the modules was placed on a CD entitled the 'Basic Biomechanics for therapists'[9] for occupational therapy students. The CD provided visual and active interaction that stimulates understanding and application of basic mechanical principles that progressed from more basic to the more complex. Students were able to access information in their own time and do self-assessment to bridge knowledge gaps[12,13]. The students were able to choose the information that they wished to access. The content of the CD included videos, animations, links to terms, related photographs and sketches and drag and drop elements. The content was divided into different learning units namely: basic mechanical principles; application of basic mechanical principles in the physical world; basic human anatomy and function and application of mechanical principles to the human body. Case studies and formative self-assessments that require applying the correct principles through drag and drop choices were incorporated throughout the CD[9].

A quasi-experimental observational study[15] was conducted to determine if the 'Basic Biomechanics for therapists'[9] CD impacted learning performance. A pre-test-intervention-post-test repeated measure timeline with a nonrandomised convenience sample was used[16]. The students' experiences of using the CD was obtained at the end of each data capturing session.

Sampling

The study targeted first year occupational therapy students in South Africa, studying at the University of Pretoria in 2010 and 2011. Capturing data in 2010 and 2011 allowed for sample size accumulation. A larger sample would allow for generalisation to the occupational therapy student population studying at this particular university. Students were provided with written and verbal information on the study at the beginning of the learning module, and requested to volunteer to participate in the study. No exclusion criteria were set for participation, which was voluntary and did not limit the teaching and learning opportunities available to all students. All the students in each of the years under consideration selected a number from a box to ensure anonymity throughout the study. Anonymous evaluations according to these numbers ensured that participants did not have undue stress and that non-participants were not discriminated against. The sample consisted of N = 81 students out of a possible of 84. Non-participants had equal access to the CD and face-to-face sessions. They completed the same pre- and post-tests together with the sample group using the selected numbers. Numbers that did not correspond with the numbers on the consent forms, were excluded from the data at the end of the module.

Ethical considerations

Consent forms were signed using selected numbers as an identifier. Participation was voluntary and data capturing sessions took place during normal scheduled class time. Ethical approval, number S163/2009, was obtained from the Ethical Committee of the University of Pretoria.

Measurement tools

A multiple-choice questionnaire (MCQ) measured performance for each learning unit[17,18]. Each set of MCQ questions were based on the 'Basic Biomechanics for therapists'[9] CD taught in the two preceding face-to-face sessions. The questions were set according to Blooms taxonomy for each learning unit by starting with questions based on basic knowledge in the first test. The second test was on a higher level being based on insight as well as knowledge[19].

A survey questionnaire evaluated participants' experiences when using the 'Basic Biomechanics for therapists'[9] CD. The educational committee of the occupational therapy department controlled the MCQs and surveys for quality. The validity and reliability of the MCQs and survey were tested in a pilot study with 33 first year volunteers in 2009. Reliability was established through comparative statistical analysis. MCQs measured a mean difference of 6.52 improvement in performance. Limited changes to the survey were indicated. The repeated measure of the data capturing process negated any individual variation that may have influenced performance. Results were more reliable than the average change between the pre-and post -tests[20,21].

Research process and data capturing

Research Process

Basic demographic information was collected at the informed consent stage. The MCQs, the 'Basic Biomechanics for therapists'[9] CD was then preloaded onto the computers allocated for the research. The research process consisted of eight face to face sessions and four computer based sessions which took place over 12 weeks.

Steps in the research/learning process

Step one

The subject was presented over a period of 12 weeks. These 12 weeks were divided into four, three week units. Each unit consisted of two face-to-face sessions of two hours each covering the content of one of the learning units as presented in the CD, starting with the basic mechanical concepts. The third week (step two to four) for each of the four units was conducted in a computer lab using the CD as learning tool.

Step two

Four sessions were held, in a computer laboratory, during which the CD was used for learning purposes. Each of these sessions was preceded by a pre-test based on the content learned during the preceding two face-to-face sessions. The student was required to answer 20 randomly selected questions from a possible 30 as part of the computer based programme. Upon completion, participants could access their total score but could not see which questions

were correct or incorrect.

Step three

The pre-test was followed by an intervention session of approximately 45 minutes during which the content based on the learning units presented during the two preceding face-to face sessions could be accessed by on the computer according to the students' individual needs. Each computer laboratory session therefore covered different information according to the progression of the curriculum as divided into the four learning units of the CD. Students were observed to see when they had all completed their perusal of the content to determine the end of the session.

Step Four

At the end of the computer laboratory session during which the learning material was accessed, the student was required to complete a second set of 20 MCQs out of a possible 30 questions, covering the material just accessed on the CD. Each session concluded with a 10-minute experience survey.

Data management and statistical analysis

Data were recorded according to the identity numbers selected by the students. All the data was captured electronically and transferred into an Excel® spread sheet for statistical analysis. The data received was recorded and analysed according to consenting participant numbers. Results of non-participants were removed before submission for analysis.

Pre-test and post-test scores were compared to measure the effect of the intervention tool on performance in the MCQs. The mean difference between the pre- and post-test scores was calculated from the test score change of each participant in each of the four learning units and recorded as continuous interval data. Pre and post-test scores were compared using paired t-tests, with a 0.05 level of significance. A two-tailed analysis accommodated positive and negative changes[22,23]. Year groups were analysed separately and together. The correlation between the pre- and post-test performance scores using a co-variance analysis with a 95% confidence interval was assessed. Mean pre-test and post-test scores were compared using a repeated measures ANOVA which account for related sample means[21]. To test for differences over the course of the intervention, the differences between the pre-tests was adjusted by conducting a global analysis using an ANOVA-change test where the adjustment of the test scores was followed by a co-variance analysis comparing adjusted pre-test scores to the final performance scores.

The results of the experience survey were measured as discrete ordinal data[24]. Values were grouped, positive were r as 1; negative and neutral r as 0. Fisher's exact tests measured associations between each question and performance test. Positive and negative responses were reflected as a percentage of the total.[25]

STATA 11[R] software was used for statistical analysis.

RESULTS

Participants were 98.8% female, 64.2% Afrikaans-speaking and 95% white, resulting in limited cultural differences within the group. (See *Table 1*)

There was a positive change in performance. The magnitude of the change varied between the four sets. The pre-test scores and post-test scores were significantly different for all sets of tests (test one $t=0.0009$, $p<0.05$; test two $t= 0.0004$, $p<0.05$; test three $t= 0.0008$, $p<0.05$; test four $t= 0.0012$, $p<0.05$) (*Figure 1*, *Table II*).

Change in test scores over the course of the intervention varied between the first and third tests and between the second and fourth tests (*Table III*). The adjusted means by test for the total sample group are reflected in *Table III*. Minimal adjustment of the pre-test sores was needed.

The combined adjusted pre-test scores were significantly lower than the combined post-test scores ($t=0.0008$, $p=0.00$). Despite this overall improvement, variation was observed in the changes for the different tests (*Figure 1* on page 39). There was a negative change or deterioration in test scores for the lower quartile of students for tests two and four.

Data were equally distributed in pre- tests one and four. Post-test scores improved after the CD format learning one to four. Test scores were positively skewed in pre-test two, but skewed towards the lower continuum in post-test two. Pre- test and post-test three scores were negatively skewed indicating that less participants experienced an improvement in their results compared to the average[26].

The experience of the participants was expressed as frequencies for each performance test (*Table IV* on page 39). Responses did not differ between tests for most questions. Responses varied between tests for questions three and ten (*Table IV*). Question three asked whether students had a perceived improvement of knowledge.

Table I: Demographic distribution of participants in the study with n=81

	Number of participants 2010 N=39	Number of participants 2011 N=42	Percentage of total
Home language			
Afrikaans	26	26	64.2
English	10	13	28.4
Other	3	3	7.4
Cultural group			
Western	38	39	95.1
Indian/Asian	1		1.2
Coloured		1	1.2
African		2	2.5

Table II: A summary of the comparative analyses for the four tests for the total n=81 sample group reflecting scores in percentages%

Test 1	Pre-test %	Post-test %	Change %
Mean	68.51	79.53	11.01
95% Confidence Interval	65.79 – 71.23	77.02 – 82.03	8.53 – 13.50
Test 2	Pre-test %	Post-test %	Change %
Mean	66.62	68.60	1.98
95% Confidence Interval	63.82 – 69.41	66.95 – 71.26	-0.61 – 4.58
Test 3	Pre-test %	Post-test %	Change %
Mean	47.66	57.98	10.32
95% Confidence Interval	44.27 – 51.05	55.09 – 60.88	6.27 – 14.37
Test 4	Pre-test %	Post-test %	Change %
Mean	53.94	55.55	1.62
95% Confidence Interval	51.19 – 56.68	53.10 – 58.01	-1.04 – 4.27

Table III: Adjusted means for the post-tests reflected as %

Test	Adjusted mean %	Confidence interval %
1	79.52	77.27 – 81.78
2	68.41	66.07 – 70.74
3	58.38	55.98 – 60.79
4	55.55	53.15 – 57.96

Table IV: Relationship between learning components and mean change in the are reflected in mean percentage measured for pre-and post-tests indicating the percentage change between the two mean scores

Components	active	reflective	sensing	intuitive	visual	verbal	sequential	global
Mean post-tests	64.78%	66.90%	65.49%	63.98%	65.83%	63.98%	64.61%	68.39%
Mean pre- tests	58.08%	61.51%	59.12%	59.53%	59.00%	59.60%	57.69%	63.59%
Change	6.70%	5.39%	6.37%	4.45%	6.23%	4.38%	6.92%	4.80%

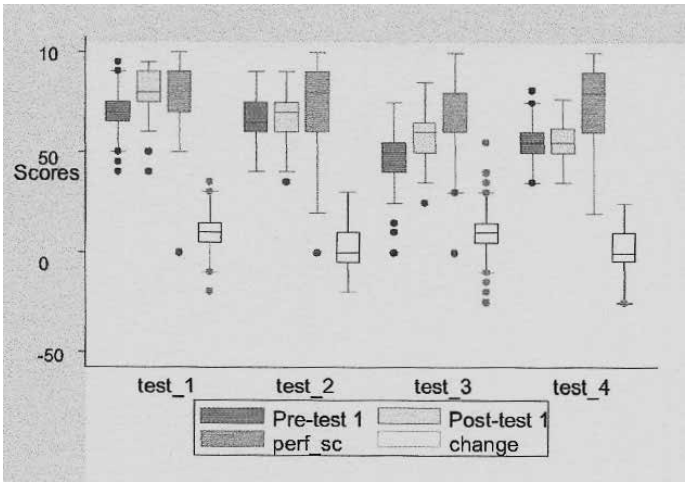

Figure 1: A box and whisker plot of the parameters of change in the mean score by test

During the first session, 81% of participants responded positively, 66% of participants in the second and third session and 57% in the final session. Question ten measured the satisfaction of using this e-learning tool. There was a decline in positive responses from 85% in session one to 64% in the subsequent three sessions. Most of the responses were positive for all questions except for question five that asked whether an auditory element should be added to the CD. Most participants (60.22%) responded negatively.

The Cronbach-alpha test analysed the internal consistency and reliability coefficient for the experience survey. The reliability coefficient increased for each session, with the first session having a moderate reliability of 0.44 and the fourth session having a reliability of 0.75. The combined reliability coefficient for all ten questions over all sessions was 0.64 indicating moderate reliability[22].

DISCUSSION

Participants that used the 'Basic Biomechanics for therapists'[9] CD significantly improved their performance by more than 5%. The improvements made during the different course components varied. Course content varied, with the first and third tests being based on factual knowledge and the second and fourth on applied knowledge. The mean improvement in tests one and three was larger than in tests two and four, indicating that the CD addressed the lower levels of Bloom's taxonomy more effectively. A gradual decrease in pre-test scores from test one to three were related to the complexity of outcomes. The positively skewed results in post-test four indicated that insights into the application were gained during the two face-to-face sessions after the third CD learning session, during which the basic knowledge on the Biomechanics of the human body was assessed and repeated. Limited improvements after the applied knowledge learning units should be investigated further. Possible improvement may be achieved through the inclusion of more elements that address the higher levels of Bloom's taxonomy where insight and application of knowledge is required[19].

The experiences of participants using the CD were mostly positive. There were more negative responses for question three which measured perceived improvement in personal understanding. Positive responses declined from 81% after session 1 to 57% after session 4. Once again, the increasing complexity of the content may be associated with decreases in perceived personal improvement. Participants rejected the suggestion of the addition of a verbal element in Question five. Question 10 reported that 85% of participants positively experienced the e-learning resource in session one. The number of positive responses declined by 64% for the subsequent three sessions. The decline could be due to boredom associated with completing the same survey every time or could indicate resistance to the use of the e-learning resource for more complex content. Students may have been more satisfied if they had had additional opportunities to use the resource but the study investigated the impact of a single e-learning session on knowledge improvement. Further investigation may be needed to confirm or deny resistance to e-learning as reported by Cameron[14], and Davies et al[8] and Barnard et al[4].

Limitations of the study

The use of a control group might have provided more definitive answers to the research questions but we could not ethically justify limiting the exposure of some students to a teaching and learning resource. Alternate testing of face-to-face and e-learning sessions was not a viable option due to the sequential nature of the content. A reliable result could not be obtained with the use of both different content and teaching methods for alternate tests. However, participants did appear to benefit from the exposure to module outcomes in an e-learning format and were enabled to set their own pace, even though it was limited due to the data capturing conditions, and had access to an additional study resource.

The limited diversity of our sample made it difficult to test the conclusions of Cameron[14] or the assumptions of Chicolo[13] and confirmed by Berger et al[8] that participants from the rural areas may be less exposed to electronic media and therefore more reluctant to use e-learning. Although identifying the possible reasons for perceived resistance[4] was beyond the scope of this study, a more diverse sample group may provide more conclusive results.

Conclusion and Recommendations

The use of the 'Basic Biomechanics for therapists'[9] CD had a positive effect on the learning of first year occupational therapy students at the University of Pretoria. The lack of diversity of the participants regarding language, ethnicity and socio-economic background limited the interpretation of results regarding possible resistance from students from poor rural compared to more affluent urban areas. E-learning provided enrichment of course content and similar teaching and e- learning resources for occupational therapy students in other courses could be developed. The study highlights the need to evaluate e-learning resources from the students' perspective so that resources remain relevant and effective. There is a need to identify sources of dissatisfaction with the e-learning resource using focus groups to assess opinions.

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