



Postural risks and musculoskeletal discomfort of three preferred positions during laptop use amongst students

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ABSTRACT

The need to access information technology in modern day occupations has encouraged the use of laptops on a daily basis. It is assumed that using a laptop in a static position over a prolonged period of time may cause postural risk as well as musculoskeletal discomfort. A previous study identified 3 most preferred positions assumed during laptop use. This study investigates the postural risk involved during laptop use by students while assuming these 3 preferred positions. It also investigates the musculoskeletal discomfort experienced by students during laptop use as well as the methods students employ to alleviate this discomfort. A quantitative, cross-sectional study design was used amongst a sample of 72 third year academic students from the University of the Free State. Data were collected by means of a self-administered questionnaire and the Rapid Upper Limb Assessment tool (RULA). For all 3 positions, 69.1% of participants scored in the postural risk category 3-4, indicating a low postural risk. Most participants (62.5%, n=45) experienced musculoskeletal discomfort with regard to pain or numbness, stiffness and spasms with 95% CI for prevalence [51.0%; 72.8%]. Stiffness in the neck was experienced by 47.2% (n=34) participants and spasms in the neck experienced by 44.4% (n=32). Tendencies and statistical significant differences are indicated between genders for adaptations made during laptop use. A recommendation for further study could be to investigate the postural risk involved while the students assume their most preferred posture within the 3 positions.

Key words: laptop, university students, Rapid Upper Limb Assessment (RULA), postural risk, musculoskeletal discomforts

INTRODUCTION

The use of laptop computers forms a significant part of modern occupations¹. The need to access information technology continues to grow on a daily basis and the advantages of laptops being portable, lightweight and less cumbersome than desktop computers, enable users to work anywhere and at any time².

Laptops have become widely used in many workplaces and educational institutions³. The Student Computers and Networks Initiative (SCAN), have established the "One student, one laptop initiative", a project in which the University of Witwatersrand as well as 12 other universities are participating^{4,5,6}. In 2013, a study done by the Centre for Teaching and Learning at the University of the Free State (UFS) indicated that 98% (n=1733) of participants in the study use and own a laptop⁷.

The index for the prevalence of musculoskeletal disorders (MSD's) and its association with awkward postural alignment in work related activities is very high⁸. In an ideal working posture the body's centre of gravity is maintained over its base of support, mechanical stress is minimised during performance at shoulder, elbow, wrist and interphalangeal joints and the body is at rest when not engaged in activity. Laptop use however, encourages postural mal-alignment such as forward flexion of the neck and head, which result in biomechanical responses that may lead to a mal-alignment in the natural curvature of the neck and spine, potentially leading to amongst others, spinal arthritis, disc degeneration and headache⁹.

A study conducted at an American college states that 67% (n=250) of participants experience discomfort or pain in the upper limbs due to computer usage¹⁰. According to Devesh & Al-Bimani¹¹, the use of computers results in musculoskeletal disorders including pain, discomfort, numbness and tingling sensations that affect the

upper limbs. Results from a study conducted by students from the Department of Occupational Therapy at the University of the Free State¹² indicate that 47.7% (n=216) of participants experienced pain while using laptops. This research further indicated that laptops are used by students in a variety of spaces for a prolonged period of time, where the user assumes positions that may negatively affect their posture. This study identified the preferred three positions assumed by students in their third year of study during laptop use, namely:

- 1) Using a laptop whilst sitting on a chair with a back rest, without the laptop resting on a table;
- 2) Using a laptop that is placed on a table whilst sitting on a chair with a back rest; and
- 3) Using a laptop whilst leaning with the users' back against a vertical surface.

Risks associated with musculoskeletal disorders (or identifying potentially hazardous risk factors at work) can be calculated using a variety of measuring instruments such as the Rapid Upper Limb Assessment (RULA). Dempsey, Maynard & McGorry¹³ indicated that the RULA is a frequently used measurement tool and is the most reliable when evaluating an individual's postural risk in a sitting position.

Considering the 3 positions mostly assumed by third year students while using their laptops, the aim of the present study was to identify and describe the a) postural risks associated with these positions, b) musculoskeletal discomforts experienced by students while assuming these positions, and c) methods used to alleviate the discomfort that students experience in these positions.



METHODOLOGY

Study design

A quantitative, cross-sectional study design was used.

Population and inclusion criteria

Students who qualified for participation in this study had to be in their third academic year of study, residing in an on-campus residence and who owned and made use of a laptop. Of a non-randomised sample of 475 third year students from the University of the Free State, Bloemfontein campus, 72 (55 females and 17 males) participated in the study. It was presumed in this study that a third year student had an established occupational pattern, as it relates to the way in which laptops are being used with reference to the posture assumed. Students with existing spinal cord injuries or disorders were excluded from the study.

Data collection instruments and procedures

Approval to conduct the study was obtained from the Ethics Committee of the faculty of Health Sciences from the University of the Free State (ECUFS 04/2014), as well as academic and management authorities on campus. Informed consent were obtained from participants, after which a date, venue and a 30 minute time slot was confirmed with each participant.

Data were collected by using 1) a self-administered questionnaire and 2) the Rapid Upper Limb Assessment (RULA)¹⁴.

The questionnaire was used to obtain background and demographic information, the uses for laptops, the location in which laptops were used, the additional items that are used while using a laptop and the manner in which they are used, the musculoskeletal discomfort experienced while using a laptop and methods used to alleviate discomfort while using a laptop.

The RULA¹⁴, a subjective observational method of posture analysis, was used to assess the musculoskeletal risks. It uses a series of illustrations of different body postures, and a numerical score is allocated to the most common observed postural alignment. Photographs of postural alignment were taken according to which the analysis of range of motion was done by using a series of 16 steps in order to calculate the postural risk score which indicates the musculoskeletal risk and the need for therapeutic intervention¹⁵. According to this method a score is calculated for 1) arm and wrist analysis, and 2) neck, trunk and leg analysis. A final RULA score was calculated by linking the wrist/arm- with the neck/trunk/leg score.

Data collection took place in each participant's residential room. Only after participants had signed the consent form did they complete the self-administered questionnaire.

Removable paper stickers were placed on the following anatomical landmarks: acromion process of the scapula; lateral epicondyle of the humerus; styloid process of the ulna and the lateral side of the metacarpophalangeal joint of the 5th finger. The participants were then requested to assume the three positions¹² in consecutive order during which photographs were taken. Firstly: using a laptop whilst sitting on a chair with a back rest, with their laptop placed on their lap. Secondly: using a laptop whilst sitting on a chair with a back rest and their laptop placed on a table. Lastly: using a laptop

whilst leaning with their back against a vertical surface. Two still photographs for each of the three positions were captured using a Fuji Film A180 digital camera. The participants were instructed to assume the mentioned three positions, during laptop use, as naturally and as comfortably as possible.

Participants were asked to assume the first position. The first still photograph was captured from a lateral view, with the camera placed 60cm away, hand held, in horizontal alignment with the lateral epicondyle of the humerus. Thereafter, the second still photograph was captured from above illustrating the participant's head; trunk and wrist positions. The participant was then asked to assume the second position. The photo-capturing process, as described above was repeated for the second position. The participants were then asked to assume the third position. Participants were limited to assume position 3 on a bed. Two photographs were captured again, while assuming the third position, one laterally and the other anteriorly. The lateral photograph was captured 35cm away in alignment with the lateral epicondyle of the humerus. The anterior photograph was captured ensuring that the participants head, trunk and wrist positions were observable. All of the above-mentioned were then printed in black and white in A4 size photographs.

For the completion of the RULA measurement tool, the range of motion (ROM) of the shoulder, elbow and wrist joint were measured on each printed photograph by using a universal goniometer. ROM measurements and position observations from each photograph were captured into the RULA. The categorised scores of musculoskeletal risks were calculated per position.

Prior to the study, a pilot study was conducted with 4 students who met the inclusion criteria. The pilot study was carried out to identify any uncertainties regarding the questionnaire and RULA data collection process in order to improve the efficiency of the implementation process. The results of the pilot study were excluded from the main study.

Data analysis

Descriptive statistics namely frequencies and percentages for categorical data and medians and percentiles for continuous data, were calculated per gender. The comparison between genders was done by means of 95% confidence intervals. The analysis was done by Department of Biostatistics.

Results

The response rate of the study was 100% with 72 participants, all of whom owned and used a laptop. Of the participants 76.4% (n=55) were females and the median age was 21 years (range = 20-23 years). Most (97.2%, n= 70) participants used their laptops for both leisure and academic purposes.

The median number of hours per day that female participants spent on their laptop was four hours (range = 1-15 hours). The male participants' results were similar with a median number of 4½ hours (range = 1-10 hours) per day. The median number of hours spent per day on a laptop for both female and male participants together was four hours (range = 1-15 hours). In addition, most participants (74.3%) spent 15 hours or more on their laptop weekly. Female results indicated a median of 21½ hours (range =

Table 1: Adaptations made during laptop use

Adaptations	Female (n=55)		Male (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Additional keyboard	0	0.0	5	29.4	[-53.1% ; -12.0%]*
Additional mouse	16	29.1	11	64.7	[-56.4% ; -8.8%]*
Additional screen	0	0.0	2	11.8	[-34.3% ; -1.1%]*
Height adjustment of the screen	15	27.7	4	23.5	[-22.0% ; 22.8%]
Use of personal chair	14	25.5	9	52.9	[-50.5% ; -20.0%]*
Pillows on the chair	26	47.3	7	41.2	[-20.0% ; 29.6%]

* Statistically significant

2-105 hours) spent on a laptop weekly with males presenting with a median of 32½ hours (range = 4-70 hours). Female and male results tended to differ with regard to hours spent on their laptops per week (95% CI [-19 ; 2]).

Considering the musculoskeletal demands of laptop use, adaptations were made by participants. (See *Table I* on page 5)

Overall 93.1% (n=67) of the participants made adaptations during laptop use. As indicated in *Table I*, a statistical significant difference existed between females and males for the following adaptations made during laptop use: additional keyboard, additional mouse, additional screen and the use of a personal chair; where males made more adaptations.

Participants further reported on musculoskeletal discomfort that they experienced during the use of laptops. (See *Table II* below)

Most (62.5%, n=45) participants experienced musculoskeletal discomfort with regard to pain or numbness, stiffness and spasms with 95% CI for prevalence [51.0% ; 72.8%].

The musculoskeletal discomfort for participants experienced most was in the neck. Pain or numbness in the neck was experi-

enced by 63.9% (n=46), stiffness in the neck by 47.2% (n=34) and spasms in the neck experienced by 44.4% (n=32) of participants. A significant difference was observed with regard to wrist pain or numbness between female (12.7%, n=7) and male (35.3%, n=6) participants. Significantly more females (86.1%, n=37) than males (62.5%, n=10) indicated they were of the opinion that there is a relation between discomfort and the use of laptops (95% CI [0.3% ; 48.5%]).

With regard to other discomforts, no female participants experienced loss of grip and inability to hold things, compared to the 11.8% (n=2) of male participants who did. Participants (n=36) also indicated that they experienced headaches (50%) and visual disturbances (38.9%, n=28) during laptop use.

Participants (n=70) made use of a variety of methods and actions to alleviate the discomforts that they experienced during the use of laptops. (See *Table III* on page 7)

Participants were asked to indicate methods they used to alleviate the discomfort they experienced with regard to pain or numbness, stiffness, spasms and other discomforts. More than half of the

Table II: Musculoskeletal discomfort experienced during laptop use

PAIN OR NUMBNESS					
	Female (n=55)		Male (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Lower back	28	50.9	9	52.9	[-26.6% ; 23.4%]
Shoulder region	30	54.6	8	47.1	[-18.1 %; 31.8%]
Neck	35	63.6	11	64.7	[-23.4% ; 25.0%]
Fingers and hands	3	5.5	2	11.8	[-29.2% ; 6.3 %]
Upper arms	1	1.8	2	11.8	[-32.6% ; 1.6%]
Lower arm	0	0.0	1	5.9	[-27.0% ; 2.2%]
Elbow	5	9.1	3	17.7	[-32.5% ; 7.0%]
Wrist	7	12.7	6	35.3	[-46.8% ; -1.3%]*
STIFFNESS					
	Female (n=55)		Male (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Lower back	21	38.2	4	23.5	[-11.8% ; 33.9%]
Shoulder region	25	45.5	6	35.3	[-16.3 % ; 32.4%]
Neck	25	45.5	9	52.9	[-31.8% ; 18.1%]
Upper arm	1	1.8	0	0	[-16.7% ; 9.6%]
Lower arm	0	0.0	1	5.9	[-27.0% ; 2.2%]
Wrist	5	9.1	1	5.9	[-18.5% ; 14.8%]
Elbow	2	3.6	1	5.9	[-23.5% ; 7.7%]
Hand / Fingers	4	7.3	2	11.8	[-27.5% ; 8.6%]
SPASMS					
	Female (n=55)		Male (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Lower back	15	27.3	2	11.8	[-9.2% ; 31.0%]
Shoulder region	18	32.7	3	17.7	[-10.7% ; 32.5%]
Neck	26	47.3	6	35.3	[-14.6% ; 34.1%]
Upper arm	1	1.8	0	0	[-16.7% ; 9.6%]
Lower arm	0	0	0	0	
Wrist	2	3.6	0	0	[-15.0% ; 12.3%]
Elbow	0	0	0	0	
Hand/fingers	4	7.3	0	0	[-11.7% ; 17.3%]

* Statistically significant

Table III: Methods and actions used to alleviate discomforts

METHODS USED TO ALLEVIATE DISCOMFORT					
	Female (n=53)		Male (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Take pain tablets	18	33.9	5	29.4	[-21.7%;25.5%]
Make adjustments to laptop	8	15.1	2	11.8	[-20.4%;18.0%]
Take frequent breaks	25	47.2	8	47.1	[-25.3%;24.8%]
Change positions during laptop use	36	67.9	9	52.9	[-9.8%;39.6%]
See an Occupational Therapist	1	1.9	0	0	[-16.6%;9.9%]
See a Physiotherapist	4	7.6	1	5.9	[-19.9%;13.1%]
See a doctor	1	1.9	1	5.9	[-25.2%;5.4%]
See a biokineticist	0	0	1	5.9	[-27.0%;2.4%]
See a Chiropractor	1	1.9	0	0	[-16.6%;9.9%]
ACTIONS USED TO ALLEVIATE DISCOMFORT					
	Female (n=55)		Male (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Reposition keyboard	4	7.3	1	5.9	[-20.2%;12.5%]
Stand up and sit down again	26	47.3	8	47.1	[-25.1%;24.8%]
Tilt screen forward	15	27.3	4	23.5	[-22.0%;22.8%]
Reduce screen brightness	6	10.9	4	23.5	[-37.1%;5.1%]
Bend head forward	11	20	2	11.8	[-15.9%;23.2%]
Loosen hand by doing air cycles	14	25.5	4	23.5	[-23.7%;20.9%]
Extend legs in front of body	23	41.8	6	35.3	[-19.8%;28.8%]
Cross arms above head	32	58.2	7	41.2	[-9.3%; 40.0%]

Table IV: RULA category scores per position

	Females (n=55)		Males (n=17)		95% Confidence Interval for the percentage difference
	n	%	n	%	
Position 1					
Score 3-4	50	90.9	17	100	[-19.6%; 10.0%]
Score 5-6	5	9.1	0	0	[-10.0%; 19.6%]
Position 2					
Score 3-4	47	85.5	14	82.4	[-13.2%; 27.5%]
Score 5-6	8	14.6	2	11.8	[-20.8%; 17.2%]
Score 7	0	0	1	5.9	[-27.0%; 2.2%]
Position 3					
Score 3-4	48	87.3	14	82.4	[-11.2%; 29.2%]
Score 5-6	7	12.7	3	17.7	[-29.2%; 11.2%]

Score 1-2 (Negligible risk), Score 3-4 (Low Risk), Score 5-6 (Medium risk), Score 7 (Very high risk)

participants (64.3%, n=45) changed positions during laptop use in order to alleviate discomfort. Overall, fewer participants consulted health practitioners in order to alleviate discomfort.

The results indicated that more than half of female participants (58.2%, n=32) used the "cross arms above head" action in order to alleviate discomforts whereas in male participants (47.1%, n=8) the actions taken mostly to alleviate discomfort was "standing up and sitting down". Participants (64.3%, n=45) indicated the priority method to alleviate discomfort as "change positions during laptop use", followed by "take frequent breaks" (47.1%, n=33), and thirdly "take pain tablets" (32.9%, n=23).

Participants were asked to indicate where they used their laptops. Most female (94.6 %, n=52) and male (94.1%, n=16) participants indicated that they use their laptop at a desk. A sig-

nificant difference was evident between the number of female (70.9%, n=39) and male (35.3%, n=6) participants who used their laptop on their bed (95% CI [8.8% ; 56.4%]. Of the 39 female participants who indicated that they use their laptop on their bed, 34 (87.2%) participants scored in the RULA category of 3-4 (low risk). (See Table IV above)

A RULA score was calculated per participant, per position to indicate the postural risk while using a laptop. The majority of participants (n=67) scored in the 3-4 (low risk) category for position 1. Only 9.1% (n=5) of females scored in the category 5-6 (medium risk).

For position 2, more than 84.7% (n=60) of participants scored in the 3-4 (low risk) category. One male participant scored in the category 7 (very high risk). With regard to position 3, it was evident

that more than 86.1% (n=62) of the participants scored in the 3-4 (low risk) category. Fifty out of the seventy two participants (69.4%) obtained scores in the RULA category of 3-4 (low risk) for all three positions.

DISCUSSION

Research results emphasise the increased presence of laptops in higher education to enhance the learning process^{16,17}. Literature provides ample evidence that report on the effect that the use of laptops has on musculoskeletal function of the human body.

This study firstly examines the postural risks and musculoskeletal discomforts associated with the three mostly assumed positions during the use of laptops by undergraduate students.

In partial agreement with findings by Chang, Amick, Menendez, Robertson and del Pino and Dennerlein¹⁸ who indicate that all college students' (n=54) RULA scores during the use of a laptop in different positions ranged between two (negligible risk) to four (low risk), results from the current study indicated that most participants fell within the low risk postural category. The difference in results is that in the current study five out of 72 participants scored in the medium risk category and one participant scored in the very high risk category.

Congruent with theories that relate to musculoskeletal function, results from the current study indicate low risk score for position two, which implies the least risk for musculoskeletal injuries. Of the three positions, this position best provides for neutral postural alignment of 90° elbow flexion, wrists in neutral position, forearms mid-way between pro- and supination, neck in 10° flexion, and gleno-humeral alignment of 0°.

For data collection purposes participants were instructed to assume the three positions namely 1) participant sitting on a chair with a back rest, without the laptop resting on a table; 2) position with laptop placed on a table whilst sitting on a chair with a back rest; 3) participant use laptop whilst leaning with back against a surface. The structured nature of the three positions, does not consider the natural positions that the participants would have assumed in each of the respective positions. In the absence of evidence regarding the effect of computer use on habitual postures¹⁹, one can argue that the three positions did not allow for individual variations, as well as the time factor, as would have occurred under natural working circumstances, and that the results could have indicated different static and movement patterns within the given positions.

The current study secondly aimed to investigate whether students presented with musculoskeletal discomforts during laptop use. Chavda and colleagues²⁰ found that up to 20% of college students suffered from musculoskeletal problems every time they worked on a laptop computer, of which neck pain (15%), shoulder and arms pain (10%) wrist and hand pain (35%) constitutes prominent results. Katz, Amick, Hupert, Cortes, Fossel, Robertson, Coley²¹ found that 53% of graduating students experienced musculoskeletal discomfort in the upper extremity during laptop use, while Harris and Straker²², in the same time period, found that 60% of a sample of 271 students reported discomfort while using their laptop computers. Jenkins and colleagues²³ found that 41% of college students experienced computer related musculoskeletal discomforts. In comparison to these results, the current study's findings were similar or higher, as most (62.5%) participants experienced musculoskeletal discomfort during laptop use, which emphasises the exponential growing number of students who report musculoskeletal discomfort during laptop use.

Differences found in gender responses were consistent with findings from numerous studies that indicate musculoskeletal discomfort experienced most commonly in females^{24,25}. However the current study indicates a tendency towards male participants reporting more pain or numbness in upper arms (11.8%), elbow (17.7%) and a significant difference in wrist (35.3%). In addition to evidence pertaining to experiences of discomfort, the

current study indicated that significantly more female (86.1%) than male (62.5%) participants were of the opinion that the musculoskeletal discomfort which they experienced was due to laptop use.

A study conducted by Jacobs and colleagues²⁶ in 2011 with University students found that discomforts can be reduced by using an adjustable chair or laptop riser, combined with ergonomic training. Noack-Cooper, Sommerich and Mirka reported that 81% of undergraduate students of the San Francisco State University use techniques such as stretching, taking breaks and modifying their position in order to alleviate discomforts²⁴. One of the methods literature indicates²⁷ is to alleviate discomfort by taking frequent breaks, while frequent standing up and sitting down were suggested by Seliger²⁸. In line with these findings, results from the current study indicate that the most common methods used to alleviate discomfort by both males and females was "standing up and sitting down" and "change position during laptop use". The current study's results further indicate that very few participants consulted health professionals to alleviate discomforts, whereas Noack-Cooper et.al²⁴ indicated that 16% of participants reported that they seek medical attention and 23% reported that they take medication to alleviate musculoskeletal discomfort.

Almost all of the participants made adaptations during laptop use which may further explain why most of the participants presented in the low risk category. More than sixty percent of male participants used an additional mouse during laptop use, whereas only 29.1% of female participants resorted to this adaptation. Both male (41%) and female (47%) participants indicated that they "put pillows on the chair". In doing so, postural alignment of 90° at hips and knees are attained, which again adheres to good neutral postural alignment and resultant least mechanical strain on joints involved. According to literature²⁷, the use of a personal chair is an important adaptation to prevent musculoskeletal discomforts. Twenty three of the participants in the current study made use of a personal chair.

A limitation of the current study is that the male-female ratio of participants was 0.3. Harris²² states that one of the weaknesses with current evidence on computer use as a risk factor is the confounding effect of gender, as gender relates to differences in the use of computers. Results from a 14 year follow-up study (n=1483) indicate that females sit more upright than males with a greater anterior pelvic tilt, and that females reported a higher 1-month prevalence of neck/shoulder pain (34.7%) than males (23.1%). Although not statistically different, findings from the current study report similar findings that indicate female participants to report stiffness in the shoulder region (45.5%) compared to males' (35.3%). However, studies with equal male-female numbers will be necessary to establish the influence of gender as it relates to a variety of aspects pertaining to the use of laptops.

Although many participants indicated that they experienced musculoskeletal discomforts during laptop use, most participants scored within a low postural risk category. It can be argued that the subjective nature of the perception of pain might be influential in the reporting of the discomfort experienced. Other possible factors may include previous repetitive strain injuries that participants could have sustained prior to data collection, which responded to the biomechanical stress when a given static position is assumed, as when working on the laptop. Musculoskeletal discomfort while working on laptops could furthermore be ascribed to injuries sustained during engagement in sporting activities which involve an inherent risk of musculoskeletal injury, due to a combination of physical overload created by over training or by the repetitive use of a joint or a particular muscle group. A further clarification scoring within the low risk category may be that most ergonomic measurement tools are not reported to consider the time-sensitive aspect of work performance in their calculations²⁹, and that longer task duration may lead to the occurrence of fatigue and resultant postural changes over time.

CONCLUSIONS AND RECOMMENDATIONS

This study showed that most students presented with low postural risk during the use of a laptop in the three most preferred positions, however outliers did exist with negligible postural risk as well as very high postural risk. This study further indicated tendencies and statistically significant gender findings with reference to musculo-skeletal discomfort experienced as well as methods and actions used by participants to alleviate the discomfort.

The three positions that students were asked to assume were firstly not necessarily one of their preferred positions, and secondly, individual habitual patterns could arguably prohibit the participants' natural response during the assumption of these positions. A recommendation for further studies could therefore be to investigate the postural risk involved while the students are allowed to assume their natural postural alignment in their engagement with real-time laptop activity, within these three positions.

The significance of this study is that it highlights postural risk factors in a categorical manner, and findings that clarify popular concerns regarding the risk of prolonged laptop use. In view of no similar study that exists, this study can be considered as a pilot studying the broader spectrum of human information technology research regarding the use of laptops amongst the student population.

ACKNOWLEDGEMENTS

The authors would like to thank management of the University of the Free State for granting permission to collect data, and the following students for their contribution: M Badenhorst, S Coetzee, A De Gouveia, J le Grange, M van Niekerk and M van Rooyen.

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