TOWARDS INNOVATIVE BEHAVIOUR FOR TECHNOLOGY STUDENTS

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ABSTRACT – Scale items related to Cognitive and Metacognitive Strategies (CMSs), Course Design Characteristics (CDCs), Knowledge Sharing Behaviour (KSB) and Innovative Behaviour (IB) can be gathered from literature and located within relevant theoretical conceptual frameworks. The aim of the study reported on in this paper was answering the research question: How can such items be re-purposed and/or modified for measuring CMSs, CDCs, KSB and IB during technology education? The importance of this research is justified in terms of the study objectives. The paper explains the design and execution of the methodology as appropriate and adequate in relation to the research question. This quantitative research design considered issues of reliability and validity. The discussion of results shows insight and originality, suggests implications and makes recommendations that are applicable and useful. The research question is answered in the conclusion, with the conclusions being justifiable in terms of the methodology and the results of the pilot study, which allowed for refining of the measures in terms of a set of original items to be used in the main study. The pilot study also contributes towards scholarly debate in fields related to CMSs, CDCs, KSB and IB.

Keywords: Innovative Behaviour (IB), Technology Students

INTRODUCTION

Problem context description

Many individual items on Likert-type scales related to Cognitive and Metacognitive Strategies (CMSs), Course Design Characteristics (CDCs), Knowledge Sharing Behaviour (KSB) and Innovative Behaviour (IB) can be gathered from an extensive literature review, as outlined in the latest and most relevant research findings on these topics.

As explained in greater detail in the next section of this paper, the scale used in this study to measure IB was based on that of Hartjes (2010), who investigated the alignment of *employee* competences with the *organizational* innovation strategy, while Morgeson and Humphrey (2006) developed and validated the Work Design Questionnaire (WDQ) as a comprehensive measure for assessing *job* design and the nature of *work*. As the latter was adapted to measure CDCs, the current limitations resulted in a need to ensure that the adaptions made in order to measure these properties with regard to **students** did not interfere with the reliability and validity of measurements. Especially the Motivated Strategies for Learning Questionnaire (MSLQ), used towards measuring CMSs (Pintrich, Smith, Garcia, & McKeachie, 1991), Morgeson and Humphrey (2006), as well as the measure of KSB by Yi (2009), were all published more than ten years ago – the continued relevance of these for 21st century students also needed to be confirmed.

The aim of the pilot study reported on in this paper therefore was to answer the research question: How can such items be re-purposed and/or modified for measuring the effects of CMSs, CDCs and KSB on the development of innovative behaviour during technology education?

Like the **problem statement** of Goosen and Ngugi (2018, p. 377), this study sought to discover a structural equation model "to elucidate the complex nature of" relationships through a better understanding of how knowledge sharing behaviour and its contextual antecedents influence students' propensity for innovative behaviour.

THEORETICAL BACKGROUND

Cognitive and Metacognitive Strategies

The MSLQ has two broad scales: those related to learning strategies and motivation (Pintrich, et al., 1991). The learning strategies scales had two components, namely resource management and cognitive and metacognitive strategies. The resource management strategies assumed four subscales: Time and study environment (8 items), effort regulation (4 items), peer learning (3 items), and help seeking (4 items).

Examples of items in the resource management strategies component include items such as "*When studying for this course, I often set aside time to discuss the course material with a group of students from the class*" on the 'peer learning' subscale. Similarly, for the 'help seeking' subscale, it had items such as "*When I can't understand the material in this course, I ask another student in this class for help*". From the wording of the question items, the two scales of 'peer learning' and 'help seeking' were deemed by the researcher to be associated with the mediating variable of KSB in the study reported on in this paper. Hence, the entire component of resource management strategies was not used.

The study adopted the cognitive and metacognitive strategies component of the MSLQ. Informed by Pintrich, et al. (1991, p. v), the cognitive and metacognitive strategies component had 31 items: Rehearsal (4 items), elaboration (6 items), organisation (4 items), critical thinking (5 items), and metacognitive self-regulation (12 items).

The original cognitive and metacognitive strategies component had the items arranged so as to mix up the questionnaire items across the subscales, and the same order was retained. The items in this scale was as indicated in Table 1 of Ngugi and Goosen (2019). There was no change to the cognitive and metacognitive strategies component and all 31 items in the scale were retained.

Course Design Characteristics

Especially the article by Parker, Van den Broeck and Holman (2017) seemingly acted as an update for the WDQ (Morgeson & Humphrey, 2006), with the former looking at work design influences in terms of a synthesis of multilevel factors that affect the design of jobs. Apart from Parker, et al. (2017), the task characteristic of *autonomy* has also received great attention in literature on motivational work design, like Battistelli, Montani and Odoardi (2013), who investigated the impact of feedback from job and task *autonomy* in the relationship between dispositional resistance to change and Innovative Work Behaviour (IWB).

Knowledge Sharing Behaviour

Recent studies, which have examined the concept of Knowledge Sharing Behaviour (KSB), include Tjoflåt, Razaonandrianina, Karlsen and Hansen (2017) and Yi (2009). The latter author conceptualized in tabular form a comparison of the four components of knowledge sharing behaviour and highlighted the associated types of channel used and the type of knowledge involved. These four components of KSB in this study are hypothesized to act as mediators of IB individually and collectively.

Innovative Behaviour

Hartjes (2010) used a case study of employees in an organization, a cable factory in Twente in the Netherlands. There is vast literature on the concept of idea generation, including Monteiro, da Silva and Capretz (2016) describing their findings from a pilot case study on the innovative behaviour of software engineers. Some of the authors, who have applied the bootstrapping method in studies related to innovative behaviour, include Mahmood and Bakar (2016), who examined the moderating role of entrepreneurial self-efficacy in terms of strategic improvisation and performance relationships.

METHODOLOGY

Ngugi and Goosen (2017, p. 82) indicated that a "cross-sectional research design was employed" for exploring relationships between "constructs, as such a design" was deemed to be suitable for data obtained over a relatively short period of time (Creswell, 2014).

Data collection

Petersen, Louw, and Dumont (2009) commented on the aspect of questionnaire length, and posited that participants are more likely to be distracted, may skip some items, loose interest in filing the questionnaire and have less concentration, if the instrument is too long. Mowbray, Boyle and Jacobs (2014) further suggested that the questionnaire length increased respondents fatigue and subsequent response quality. Conversely, instruments that are relatively short tend to be less intimidating and respondents have a higher chance of answering all the items in the scale in full. To make the questionnaire acceptable to respondents, by them taking an acceptable amount of time to complete the questionnaire, and retain all the exogenous and endogenous constructs,

some scales were shortened, while others were designed to have a specified reduced number of items, in comparison to the full-scale measures.

Research instruments

In terms of the accuracy of input, out of range values and multiple response and multiple dichotomy analysis, care was taken to score in reverse order all negative-worded items, which had the net effect of having higher values representing higher levels of agreement with the questionnaire items (Coakes & Steed, 2003).

Sampling

The pilot study utilised a convenience sample of 38 respondents drawn from one private university, namely Mount Kenya University. Scale reduction analysis was used to generate the inter-item total correlation and Cronbach alpha reliability coefficients, as presented in Ngugi and Goosen (2017) and (2018).

Research population

A private university was chosen to avoid contaminating the sample population for the main study.

During the piloting stage, verbal discussion with the respondents suggested that the questionnaire length was intimidating, as it was too long and had several similar question items that appeared repetitive. Based on examining the item-to-total correlations values, the final questionnaire items were reduced. In addition, in order to enhance the content **validity**, academic staff in Information Technology programmes were requested to judge how well the items were a true representation of the principal constructs. New criteria for assessing discriminant **validity** in variance-based Structural Equation Modelling (SEM) were also sought (Henseler, Ringle, & Sarstedt, 2015).

One way to reduce the number of items in a variable is examining the item-total correlation. The coefficient alpha values for each dimension and the total scale were as presented in Table 1.

Table 1: Reliability values for scales during piloting.

Scale	Reliability (Cronbach's Alpha)	No of items
Innovative Behaviour (IB)	.724	11
Knowledge Sharing Behaviour	.889	20
Cognitive and Metacognitive Strategies	.945	31
Course Design Characteristics	.852	44
• Task characteristics	• .819	• 25
• Knowledge characteristics	• .793	• 19
Total		106

The reliability analysis for the innovative behaviour scale was as presented in Table 2.

Table 2: Reliability analysis for the innovative behaviour scale

	How often do you…	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1.	…look for opportunities to improve an existing process, technology, product, or service?	32.93	39.456	.330	.710
2.	…recognize opportunities to make a positive difference in IT software development, project development, class, or the society at large?	32.48	38.875	.471	.693
3.	…pay attention to non-routine issues related to my course, class, department, or the market place for IT products?	33.07	43.764	.043	.748
4.	…search out new IT methods, techniques, or instruments?	33.07	35.994	.466	.689
5.	…generate original solutions to Information Technology problems?	33.22	34.564	.604	.665

6.	…find new approaches to execute Information Technology tasks?	33.37	37.242	.479	.688
7.	…encourage key class members to be enthusiastic about innovative ideas?	33.22	39.333	.291	.717
8.	…attempt to convince people to support an innovative idea?	32.74	40.123	.268	.719
9.	…systematically introduce innovative ideas into Information Technology course practices?	33.15	40.746	.271	.718
10.	…contribute to the implementation of new ideas?	32.89	38.641	.422	.697
11.	…put effort into the development of new things?	32.81	38.695	.455	.694

Although the scale was reliable and had met the cut off criteria for internal consistency reliability value of 0.7, some of the items (3, 7, 8 and 9) had low item-total correlations, below 0.3. A closer examination of the items revealed the need to reword the items. The new item was thus reworded as follows "pay attention to non-routine issues related to my project in software development". The IB scale had 2-3 items per variable, which was acceptable, and the scale was not reduced.

The reliability analysis for the knowledge sharing behaviour scale was as presented in Table 3. The negative values of the item-total correlations for questionnaire items 2 and 3 were due to negative wording. The low values of the item-total correlation, however, demanded that items 1, 2 and 3 be deleted.

The reliability analysis for the task characteristics subscale was as presented in Table 4. Five items (1, 4, 6, 14 and 17) had item-total correlations below 0.25 and were excluded from the study. Although items 2 and 3 also had low item-total correlations, they were retained, as their low item-to-total correlation was thought to be related to the reverse wording in the questionnaire items. Removal of the negatively correlated item 1 was expected to resolve problems in measurement of the autonomy subscale of the task characteristics subscale. The item "*The project work is arranged so that I can do a complete piece of work from beginning to end*" was also deleted, as it had an item-total correlation of 0.295 and was similar in meaning to item "*the project work involves completing a piece of work that has an obvious beginning and end*". finally, the item "*the project work requires that i only do one task or activity at a time*" was also deleted.

DISCUSSION OF RESULTS

Based on the information gathered during the piloting stage, it was noted that some the subscales had too many items, and/or some, which were repetitive. One critical case was three of the subscales of KSB, which had eight or seven items respectively. The course design characteristics scale also had a total of 44 items, from the two subscales of task and knowledge characteristics.

Table 3: Reliability analysis for the knowledge sharing behaviour scale

	How often do you…	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1.	...submit documents and reports to lecturers?	58.92	225.993	.053	.898
2.	...share findings in class journals, magazines, or newsletters?	59.75	231.152	-.058	.898
3.	...share documentation from personal files related to current Information Technology course?	59.38	230.071	-.035	.899
4.	… contribute ideas and thoughts to class online forums?	60.25	213.413	.567	.883
5.	…keep others updated with important technological information through online discussion boards?	59.38	201.375	.637	.879
6.	...express ideas and thoughts in class /technological discussions?	59.17	206.754	.644	.880
7.	...propose problem-solving suggestions related to my studies?	59.13	206.636	.620	.880

8.	...answer questions of others in class meetings and other forums?	59.29	209.259	.535	.882
9.	...share success stories that may benefit the class?	58.92	204.601	.624	.880
10.	...reveal past personal failures or mistakes in class /technology meetings to help others avoid repeating these?	59.08	201.732	.646	.879
11.	...have online chats (e.g. Facebook, Twitter, Hangouts) with others to help them with their technology -related problems?	58.46	197.998	.654	.878
12.	...share ideas and thoughts on specific topics through email communication?	59.21	200.955	.635	.879
13.	…spend time in personal conversation (e.g. discussion over breaks, through telephone) with others to help them with their course-related problems?	59.50	216.609	.396	.886
14.	…keep others updated with important class /technological information through personal conversation?	58.96	206.911	.658	.879
15.	…share passion and excitement on some specific subjects with others through personal conversation?	58.75	209.326	.482	.884
16.	…share experiences that may help others avoid risks and trouble through personal conversation?	58.75	199.065	.689	.877
17.	…meet with classmates and other IT techies to create innovative solutions for problems related to our studies	59.42	203.471	.655	.879
18.	…meet with classmates and other IT techies to share own experience and practice on specific topics with common interests?	59.46	204.346	.593	.880
19.	…meet with classmates and other IT techies to share success and failure stories on specific topics with common interests?	59.75	203.674	.668	.878
20.	…support development of IT skills for my classmates and others?	58.83	211.449	.497	.884

Table 4: Reliability analysis for the task characteristics subscale

		Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1.	The project work allows me to make decisions about how to schedule my project/studies	71.26	72.747	-.001	.822
2.	The project work allows me to decide on the order in which things are done	71.48	70.715	.123	.822
3.	The project work allows me to plan how I do my studies	71.35	72.692	.024	.821
4.	The project work gives me a chance to use my personal initiative or judgment in carrying out related tasks	71.13	72.755	-.018	.824
5.	The project work does allow me to make a lot of decisions on my own	72.35	67.964	.301	.815
6.	The project work provides me with significant autonomy in making decisions	71.30	71.221	.121	.821
7.	The project work allows me to make decisions about what methods I should use to complete my project/studies	71.35	68.055	.271	.817

8.	The project work gives me considerable opportunity for independence and freedom in studies	71.22	68.451	.411	.811
9.	The project work allows me to decide on my own how to go about doing the work	71.35	66.419	.452	.808
10.	The project work involves a variety of tasks related to project/studies	71.22	64.360	.619	.801
11.	The project work involves doing a number of different things	71.43	66.621	.369	.812
12.	The project work does require the performance of a wide range of tasks	71.91	68.356	.216	.821
13.	The project work involves performing a variety of IT tasks	71.30	64.585	.541	.804
14.	The project work is likely to significantly affect the lives of other people	70.91	72.447	.021	.823
15.	The project work itself is very significant and important in the broader scheme of things	71.30	62.858	.560	.802
16.	The project work has a large impact on people outside the class	71.04	63.953	.614	.801
17.	The project work has a significant impact on people outside the class	71.30	68.858	.249	.817
18.	The project work involves completing a piece of work that has an obvious beginning and end.	71.74	65.474	.469	.807
19.	The project work is arranged so that I can do a complete piece of work from beginning to end.	71.70	67.949	.295	.816
20.	The project work provides me the chance to completely finish the pieces of work that I begin.	71.35	67.874	.415	.811
21.	The project work does allow me to complete what I start.	72.35	66.692	.342	.814
22.	The technological activities provide direct and clear information about the effectiveness of my project.	71.30	62.676	.688	.797
23.	The project work itself provides feedback on my performance.	71.48	66.170	.451	.808
24.	The project work itself provides me with information about my performance	71.26	64.565	.618	.801
25.	The project work requires that I only do one task or activity at a time	72.04	67.680	.301	.815

Table 5: Reliability analysis of knowledge characteristics subscale

		Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1.	The tasks are simple and uncomplicated	49.81	50.662	.345	.785
2.	The project work comprises relatively complicated tasks	49.57	49.957	.464	.779
3.	The project work involves performing relatively simple tasks	49.76	51.590	.299	.788
4.	The project work requires me to monitor a great deal of information.	49.62	47.848	.510	.774
5.	The project work requires that I engage in a large amount of thinking.	49.52	49.762	.375	.783
6.	The project work requires me to keep track of more than one thing at a time.	49.57	49.557	.414	.781
7.	The project work does require me to analyse a lot of information.	50.67	52.733	.200	.793
8.	The project work involves solving problems that have no obvious answer.	49.95	51.648	.283	.789

9.	The project work requires me to be creative.	49.43	44.557	.618	.763
10.	The project work often involves dealing with problems that I have not met before.	49.48	52.562	.200	.793
11.	The project work requires unique ideas or solutions to problems.	49.71	48.514	.512	.774
12.	The project work requires a variety of skills.	49.52	50.662	.301	.788
13.	The project work requires me to utilize a variety of different skills	49.52	46.662	.559	.769
14.	The project work does require me to use a variety of complex or high-level skills.	50.00	55.500	.082	.815
15.	The project work requires the use of a number of skills.	49.52	52.362	.237	.791
16.	The project work is highly specialized in terms of purpose, tasks, or activities	49.52	48.862	.451	.778
17.	The tools, procedures, materials used in my study are highly specialized in terms of purpose.	49.57	53.057	.224	.791
18.	The project work requires very specialized knowledge and skills.	49.52	49.962	.306	.789
19.	The project work requires a depth of knowledge and expertise.	49.43	46.657	.691	.763

The results of scale reduction using Cronbach alpha reliability analysis, with a focus on items with low item-to-total correlation, in terms of the scales, subscales and number of items in the reduced versions were as indicated in Tables 6 to 8.

These final items were selected based on content and face validity, as well as items highlighted by low and/or negative scores for item-to-total correlation scores. This had the effect of increasing the quality of responses and the completion of items significantly. Furthermore, the questionnaire items were presented on two A4 size papers that were printed on both sides, so as not to intimidate respondents.

During the pilot, each the four KSB sub-constructs had five items each. The reduction in the number of items from 20 to 16 was significant, representing a decrease of 25% (see Table 6).

Table 7 shows that the reduction in the number of task characteristics items from 24 to 17 represented a decrease of 29%, which was significant. After the pilot, the autonomy section had six items, composed from Scheduling Autonomy, Decision-Making Autonomy, and Methods Autonomy. The other sections had either two or three items each.

The reduction in the number of knowledge characteristics items (see Table 8) from 20 to 12

Table 6: Items in the reduced version of the knowledge sharing behaviour scale.

Subscale	No of Items in Yi (2009)	No of Items used in Pilot	No of Items in Reduced Version
Written Contributions	5	5	2
Class Communications	8	5	4
Personal Interactions	8	5	5
Communities of Practice	7	5	5
	28	20	16

Table 7: Items in the reduced version of the task characteristics subscale.

Subscale	Original No of Items	No of Items in Reduced Version
Scheduling Autonomy	3	2
Decision-Making Autonomy	3	1

Methods Autonomy	3	3
Task Variety	4	3
Task Significance	4	2
Task Identity	4	3
Technology Feedback	3	3
	24	17

Table 8: Items in the reduced version of the knowledge characteristics subscale.

Subscale	Original No of Items	No of Items in Reduced Version
Complexity	4	1
Information Processing	4	3
Problem Solving	4	3
Skill Variety	4	3
Specialization	4	3
	20	13

represented a decrease of 35%, which was significant. The Complexity and Information Processing sections had items reduced from eight to four (50%).

CONCLUSION

Linking the results to concepts from the theoretical framework, the pilot study reported on in this paper contributes to scholarly debate in fields related to cognitive and metacognitive strategies, course design characteristics, knowledge sharing behaviour and innovative behaviour, supporting arguments in favour of the mutual interrelationships between these variables in earlier research, as well as confirming that the revised items in the context of the current study also retain these.

The research question is answered in this conclusion, with the conclusions being justifiable in terms of the results of the pilot study, which allowed for refining of the measures in terms of a set of original items to be used in the main study: The four latent variables of the study ended up containing 88 Likert scale question items, which respondents were requested to answer, categorised into four Likert scales. In terms of the justification of the methodology used, the most important concern and challenge was how to increase the response rate, through a meticulous examination of the questionnaire length and total time required to answer the items.

In terms of increasing the depth of research, the authors wish to point out that Analysis of Moment Structures (AMOS) had been widely used in SEM research that includes missing data, as it provides estimates that are efficient and consistent, due to its use of Full Information Maximum Likelihood (FIML) estimation (Henseler, et al., 2015).

The significance of the refined questionnaire items is justified in terms of the objectives of the pilot study, which included to measure the reliability and explore the face validity of the suggested scales, ensure that the final questionnaire was of reasonable length, increasing participation rates, and reduce the possibility of errors caused by respondent fatigue, or declining interest.

Some items in the motivation scales of the MSLQ were deemed by the researcher to be closely related to the task characteristics subscale of the CDCs scale. For instance, the Task Value subscale had items such as *"I think the course material in this class is useful for me to learn"*, which closely relates to the task characteristics subscale of the present research. Hence, the motivation scales were not used as a subscale. Regarding making recommendations that are applicable and useful, there may be scope for further research to explore the relationship between these variables of the motivational scales and the task characteristics subscale used in the present research.

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