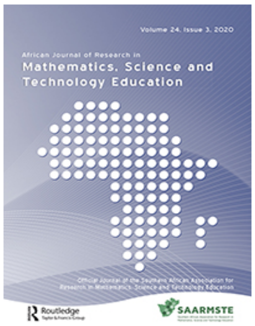

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Research Article

The Relationship between Motivation for, and Interest in, Learning Physics among Lower Secondary School Students in Uganda

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Motivation and interest affect students' learning especially in Physics, a subject learners perceive as abstract. The present study was guided by three objectives: (a) to adapt and validate the Science Motivation Questionnaire (SMQ-II) for the Ugandan context; (b) to examine whether there are significant differences in motivation for learning Physics with respect to students' gender; and (c) to establish the extent to which students' interest predicts their motivation to learn Physics. The sample comprised 374 randomly selected students from five schools in central Uganda who responded to anonymous questionnaires that included scales from the SMQ-II and the Individual Interest Questionnaire. Data were analysed using confirmatory factor analyses, *t*-tests and structural equation modelling in SPSS-25 and Mplus-8. The five-factor model solution of the SMQ-II fitted adequately with the present data, with deletion of one item. The modified SMQ-II exhibited invariant factor loadings and intercepts (i.e. strong measurement invariance) when administered to boys and girls. Furthermore, motivation for learning Physics did not vary with gender. Students' interest was related to motivation for learning Physics. Lastly, although students' interest significantly predicted all motivational constructs, we noted considerable predictive strength of interest on students' self-efficacy and self-determination in learning Physics. Implications of these findings for the teaching and learning of Physics at lower secondary school are discussed in the paper.

Keywords: *Confirmatory factor analyses; interest in learning physics; lower secondary school; measurement invariance; science motivation questionnaire*

Introduction

In recentt years, there has been a global outcry over the poor achievement of students in Science subjects (Keller et al., 2017) and especially Physics (Barmby et al., 2008; Oon & Subramaniam, 2011) at tertiary and secondary school levels. In addition, major concerns have been expressed about the rapid decrease in the number of students opting for Physics-oriented courses at tertiary institutions of learning (Osborne et al., 2003) in both developed and developing countries (Gudyanga et al., 2015). Uganda has had a rough share of this experience. For instance, for the last decade Physics has ranked as the worst performing subject in the final examination at secondary school level (UNEB, 2017).

Poor achievement in Physics is influenced by the students' motivation for and interest in learning Physics (e.g. Keller et al., 2017; Potvin & Hasni, 2014, Taun et al., 2005). This lack of motivation and interest may interfere with the students' decision making and behaviour towards Physics learning, especially in girls (Schumm & Bogner, 2016). Yet little is known about motivation for and interest in learning Physics in Sub-Saharan Africa. In addition, there are no validated measures to assess students' motivation and interest. Thus there is need to develop instruments with sound psychometric properties to aid the assessment of students' motivation before appropriate interventions such as tailored teaching methods and programmes such as inquiry-based learning can be implemented and evaluated. Therefore the present study was conducted with three main objectives: (a) to adapt and validate the Science Motivation Questionnaire (SMQ-II) when used to assess motivation to learn Physics among secondary school students in the Ugandan context; (b) to examine significant differences in motivation for learning Physics with respect to students' gender; and (c) to establish the extent to which students' interest predicts their motivation to learn Physics.

Secondary School Physics Education in Uganda

At secondary school level, the Ugandan Physics curriculum is divided into two dimensions: (a) Ordinary secondary school curriculum – from 8th to 11th years of formal schooling; and (b) Advanced secondary school curriculum (from 12th to 13th years of formal schooling). With the interest in innovation and expansion in Science and Technology in the country, in 2005 the Ugandan government adopted the Compulsory Science Policy, in which all Science subjects including Physics were made compulsory from 8th to 11th year (Asiimwe, 2013). Following the pronouncement of the Compulsory Science Policy, various strategies and innovations have been put in place by the government to foster students' achievement in Science subjects. These among other things include the recruitment of more Science teachers and the construction of more Science laboratories.

However, in spite of the above-mentioned efforts by the Ugandan government, statistics from the Uganda National Examinations Board (UNEB) – the board responsible for national education evaluation and assessment – indicate that for the last decade Sciences has been the most poorly performing subject nationwide with Physics ranking as the worst performing overall at lower secondary school level (e.g. UNEB, 2017). For instance, in 2015, of the 303,237 students who sat for the Physics national exam, only 15.5% passed with credits and distinctions (marks between 40 and 100%), while in 2016, of 323,276 students, only 9.7% passed with credits and distinction. This implies that only 15.5 and 9.7% of the students were eligible to take Physics at Advanced level in the respective years. Several reports have attributed this poor achievement in Science to a number of factors such as: (a) low self-efficacy (Asiimwe, 2013); (b) poor learners' attitudes towards Science subjects; (c) the abstract nature of Science subjects; and (d) failure of learners to relate Science subjects to real-life experiences (Kwesiga, 2002). However, to the best of our knowledge, no study has been conducted to assess students' motivation for and interest in learning physics.

Theoretical Framework

We grounded our study in the social-cognitive theory of learning (Bandura, 1986). In this framework, motivation to learn science is often defined as 'the internal state that arouses, directs and sustains science learning behavior' (Glynn et al., 2011, p. 1160). Motivation for science learning includes intrinsic motivation, self-determination, self-efficacy, goal motivation and career motivation. Intrinsic motivation is the drive students feel when they do something because it is inherently interesting and enjoyable (Ryan & Deci, 2000). Self-determination refers mostly to the effort and commitment students show in Physics classes (Schumm & Bogner, 2016). Self-efficacy is the individual's perception of competence to accomplish Physics tasks and attain certain results (Pajares, 1996). In a school setting, learners are motivated to achieve tangible outcomes. The learner outcomes can be short term such as Physics grades (grade motivation) or long term, for example, careers in Physics (career motivation).

Hidi and Renninger (2006) have conceptualised interest in science as 'both the state of heightened affect for Science and the predisposition to re-engage science again' (p. 114). In the context of physics, learners with high interest in learning Physics use a variety of adaptive learning strategies to achieve their set goals, and are highly self-regulated compared with their counterparts with low interest.

Differences in Motivation Towards Science Learning Between Boys and Girls

Previous studies have reported motivational differences that favour male students in learning of Science and Math among students at secondary school level (e.g. Meece & Jones, 1996), although other studies indicate the contrary (e.g. Ardura & Pérez-Bitrián, 2019; Opolot-Okurut, 2010). In Germany, Schumm and Bogner (2016) noted that there was no gender difference in intrinsic motivation, career motivation and overall motivation when they assessed the motivation of 232 tenth graders. However, gender differences existed in self-determination and self-efficacy with male students having lower scores compared with those of female students in self-determination. These findings were consistent with a study by Ardura and Pérez-Bitrián (2018) using a sample of Spanish students. Also in both studies, male students had higher scores of self-efficacy as compared with female students. These findings about higher efficacy and confidence beliefs among boys compared with girls have been supported in studies in various countries such as the USA (Britner & Pajares, 2001) and Uganda (Opolot-Okurut, 2010).

On the contrary, when Salta and Koulougliotis (2015) assessed students' motivation in 330 secondary school students in Greece, female students had significant higher scores on self-determination than the male students. Further, no gender differences were observed in students' self-efficacy. Rather, gender differences were noted in intrinsic motivation, with girls being more intrinsically motivated than boys.

Glynn et al. (2011) noted that boys had better motivational orientations towards Physical Sciences compared with girls whose motivational orientations were more inclined to Biological Sciences. Additionally, among low-ability Science students, boys tend to show higher mastery motivation compared with girls (Meece & Jones, 1996).

As discussed above, studies on the role of gender in students' motivation to learn Science and Physics have reported inconsistent findings. These studies seem to imply that this relation is context-dependent. In the Ugandan context, studies investigating motivation in Science learning at secondary school level have mainly been conducted in Mathematics (e.g. Opolot-Okurut, 2010), leaving a knowledge gap on the gender differences in motivation towards learning Physics. The present study, therefore, responds to the above research gap. Furthermore, findings from the present study will aid in developing interventions that are consistent with the students' gender motivational requirements.

Interest Predicting Students' Motivation for Learning Science

Previous studies have noted associations between students' interest and their related motivation for learning (e.g. Schiefele, 1991). As to whether interest predicts motivation or vice versa, there have been many controversies since interest is content and context related (Schiefele, 1991). Some studies have revealed that interest in science predicts motivation (e.g. Ardura & Pérez-Bitrián, 2019; Hidi & Renninger, 2006), while other studies indicate otherwise (e.g. Leaper et al., 2012). Further, some longitudinal studies indicate reciprocal prediction between interest and motivation (e.g. Niemivirta & Tapola, 2007). Hardly any research has been done to uncover the predictive relation between interest in, and motivation for learning Physics more specifically in developing countries like Uganda. Thus, the current study sought to uncover this relationship.

The SMQ-II

The original 30-item SMQ developed in 2006 for college students by Glynn and Koballa (2006) had five subscales (i.e. intrinsic motivation, extrinsic motivation, personal relevance of Science learning, self-efficacy and anxiety about Science assessment) with each subscale comprising five items answered on a five-point Likert scale ranging from 1 (*never*) to 5 (*always*). However, upon conducting an exploratory factor analysis on the SMQ, results found the construct validity of the SMQ significantly wanting (Glynn et al., 2009). Based on the Classical Test theory, Glynn et al. (2011) revised the SMQ. Further validation studies by Glynn and colleagues in 2015 using a sample of 680 US undergraduate students indicated that the SMQ-II exhibited high construct validity and reliability when used within the US context.

However, Glynn and colleagues recommended further validation studies in different study contexts and Science disciplines for continued improvement of its construct validity in different settings. To this end, various researchers have adapted and validated the SMQ-II in different languages such as: (a) Greek (Salta & Koulougliotis, 2015); (b) German (Schumm & Bogner, 2016); and (c) Spanish (Ardura & Pérez-Bitrián, 2018). The SMQ-II has also been adapted and validated using several students populations such as secondary school students (Ardura & Pérez-Bitrián, 2018; Salta & Koulougliotis, 2015), and various subjects, such as Chemistry (e.g. Salta & Koulougliotis, 2015). The SMQ-II yielded different results when it was adapted and validated in different countries. For example, SMQ-II subscales yielded higher reliability coefficients (indicated by high Cronbach alphas) when used in Spain than when it was used in Greece, although in both countries it was used among high school students studying Chemistry. Also according to the subscale, intrinsic motivation was highest in the Greek sample compared with the Spanish group, where it was lowest.

In Germany, Schumm and Bogner (2016) revealed that two items (22 and 25) of the German version of the SMQ-II had lower loadings that deviated from the hypothesised model by Glynn and colleagues, and consequently, these items were dropped, shortening the instrument further. Further inconsistent differences were noticed when comparing the findings of the German sample with those of the Spanish and Greek samples. In the Greek version, girls had higher self-determination, career motivation and intrinsic motivation than the boys, whereas, in the Spanish and German versions, girls only scored more highly on grade motivation than boys. Further, differences in measurement invariances, reliability and correlations within the components of motivation have been identified when the SMQ-II is used in different countries and study populations.

It is, therefore, important to validate this instrument to ascertain its psychometric soundness before it is used within any study population and context. Further, the above studies have been conducted in the American or European educational contexts which differ significantly from the Ugandan context under consideration in the present study. Therefore, we could not rely on the findings of validation studies from the above contexts to inform us about the fitness of the SMQ-II in the Ugandan context. Thus, we tested the instrument to determine whether it was fit for our target group in the Ugandan setting. Moreover, validation of the SMQ-II in the Ugandan context allows for cross-cultural comparisons on different motivational aspects between Ugandan students and those elsewhere.

Methods

Sample

Data were collected from five secondary schools (three in urban setting while two were in rural setting) located in Masaka district, Central Uganda, with a total number of approximately 1,580 students studying in Grade 8 of formal schooling. Within each school, all of the Grade 8 students present that day were given a questionnaire to fill in. We obtained data from 379 students from the above study population. Data from five female students were excluded because they did not sign the consent forms. In total, data from 374 students with the mean age of 14 years (SD = 1.59; range 13–19 years) were used for analyses. The majority of the participants (206 students; 56%) were females. There were more day students ($n = 194$, 51%) than boarding students ($n = 185$, 49%).

Procedure

Ethical approval for the study was obtained from Mbarara University of Science Technology, Research Ethics Committee. The study team visited the selected schools where they explained relevant details about the study to the school management as a way of eliciting their support. We had discussions with selected students where we explained the purpose of the study, the study objectives, sampling criteria and ethical considerations, among others. The students asked study-related questions that were responded to by the study team. Students who provided consent in addition to parental consent were enrolled to the study. Students took about 20–30 min to respond to the anonymised combined questionnaire.

Instrument

We elicited demographic characteristics like gender, age and residence status of the participants. Students' motivation was assessed using the 25-item SMQ-II (Glynn et al., 2011). We adapted the SMQ-II to our study purpose by replacing the word 'Science' with 'Physics'. Additionally, we replaced the word 'grade A' with 'between 75% and 100%' since at lower secondary level in Uganda, grades are in percentages. Each of the five subscales comprises five items (see Table 2) answered on a five-point Likert-scale ranging from 1 (*never*) to 5 (*always*).

The seven-item Individual Interest Questionnaire (IIQ) was developed and validated by Rotgans (2015). Items on the IIQ (see Table 5) are scored on a five-point Likert scale ranging from 1(*not true at all*) to 5 (*very true for me*). Average scores in range of 1–2 indicate low interest while average scores in the range 4–5 indicate high interest levels. Reliability coefficients for the scales used in the present study were acceptable and ranged between 0.66 and 0.78 (see Table 5). On validating the IIQ in the Ugandan context, the fit indices indicated that it was fit for the population used (comparative fit index, CFI = 0.965, Tucker–Lewis index, TLI = 0.948, root mean square error of approximation, RMSEA = 0.048 and standardised root mean square residual, SRMR = 0.036).

Data Analyses

Initially, data were screened for outliers, normality and missing values. No outliers were detected in our dataset. We noted that some items had missing values of <0.5%, and these were handled by the full-information-maximum-likelihood method as it is more efficient compared with other techniques such as list-wise deletion (Usher & Pajares, 2009). Additionally, we screened the data set for its suitability for factor analysis using the Kaiser–Meyer–Olkin measure of sampling adequacy and the Bartlett's test of sphericity. These initial analyses were conducted in SPSS-25. Our data passed both tests (Kaiser–Meyer–Olkin = 0.93; Bartlett's test of sphericity, $\chi^2 = 2571.65$, d.f. = 276, $p < 0.05$), indicating that the correlation matrix of items was of adequate quality. After ascertaining the suitability of the data for factor analysis, we randomly split our sample into two groups ($n_1 = 196$, $n_2 = 178$) for confirmatory factor analysis (CFA). We selected CFA because: (a) our study aimed at testing the five-factor model proposed by Glynn et al. (2011) to physics learning; (b) CFA provides a rigorous test of equivalence across the groups (Salta & Koulougliotis, 2015); and (c) CFA is preferred when measurement models have strong hypotheses regarding the number of latent variables in the model (Usher & Pajares, 2009). Subsequently, using the whole sample, a multigroup CFA in order to examine whether the items' factor loadings and intercepts are invariant across female and male participants was conducted before conducting mean comparisons in the subsequent steps. *t*-Tests were used to analyse differences between motivation to learn Physics and gender.

Lastly, before running the prediction model, we conducted Pearson's correlation coefficient analyses between the motivational components and students' interest to learn Physics in order to determine associations between these variables. We then assessed the measurement model to examine its suitability in estimating the structural model in the subsequent phase. After obtaining a perfectly fitting model, a structural model was estimated. Model estimations were conducted using Mplus.8 (Muthén & Muthén, 2017). Model fit evaluations during CFAs and structural models were based on model fit indices including the CFI, TLI, RMSEA and SRMR. A combination of the above fit indices minimises Type I and Type II errors (Hu & Bentler, 1999). We followed the model fit criteria suggested by Hu and Bentler (1999) that includes CFI and TLI values ≥ 0.90, SRMR ≤ 0.08 and RMSEA ≤ 0.06.

Results

Confirmatory Factor Analysis

After deleting item 'My career or job will involve physics' owing to very high correlation with the item 'I will use physics problem solving skills in my career' in prior analyses, the five-factor model structure fitted adequately with the present data since all of the above fit indices were within acceptable ranges for both validation samples (see Table 1) – providing evidence of construct validity of the modified version of the SMQ-II. The factor loadings were all above the acceptable value (see Table 2).

Gender Differences in Motivation to Physics Learning

Before we proceeded to assess the differences in motivational components with gender, we first examined measurement invariance of the instrument among boys and girls to ascertain whether boys and girls interpreted the items of the Physics version of the SMQ II in a similar way. As indicated in Table 3, the instrument demonstrated strong measurement invariance; hence, mean comparisons based on student gender could be carried out in the next steps.

There were no statistically significant differences for gender in students' motivation for physics learning (see Table 4). Nevertheless, female students scored slightly higher on all motivational components compared with male students. Generally, the mean score of students' intrinsic motivation towards Physics learning was lowest while their mean score of grade motivation was highest of the motivational components for both boys and girls.

Prediction of Students' Motivation to Learn Physics

Preliminary Results

Results indicated significant positive correlations between the study variables (see Table 5). We also noted that self-efficacy had stronger correlations with other components of motivation (*r* ranging between 0.56 and 0.65, $p < 0.01$). The results of correlations (see Table 6) indicated that interest could be used to predict students' motivation for learning Physics.

Testing the Measurement Model

The measurement model fitted adequately with the data as indicated by the acceptable fit indices (CFI = 0.92, TLI = 0.91, SRMR = 0.05, RMSEA = 0.04). Factor loadings were also adequate since values were above 0.40 (see Tables 2 and 6).

The Structural Model

The model fitted with the data adequately (CFI = 0.92, TLI = 0.91, SRMR = 0.05, RMSEA = 0.04). In this model, students' interest significantly predicted all of the indicators of students' motivation towards learning Physics including intrinsic motivation ($\beta_{standardised} = 0.80$, $p < 0.001$; $R^2 = 0.644$), self-efficacy ($\beta_{standardised} = 0.58$, $p < .001$; $R^2 = 0.338$), self-determination ($\beta_{standardised} = 0.71$, $p < .001$; $R^2 = 0.505$), career motivation ($\beta_{standardised} = 0.52$, $p < 0.001$; $R^2 = 0.275$) and grade motivation ($\beta_{standardised} = 0.46$, $p < .001$; $R^2 = 0.212$). As shown in Figure 1, interest showed very stronger contributions and explained more variance in students' intrinsic motivation and self-determination compared with other motivational variables.

Table 1. Summary of goodness-of-fit statistics

	Sample size	Chi-square value	CFI	TLI	RMSEA	SRMR
Sample 1	196	320.84	0.93	0.92	0.06	0.04
Sample 2	178	316.16	0.92	0.91	0.06	0.04

CFI, comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; SRMR, standardised root mean square residual.

Table 2. Science Motivation Questionnaire (SMQ-II) physics version: items and factor loadings resulting from confirmatory factor analyses on the two separate samples and the whole sample

		Factor loadings		
Item number	Item statement	Sample 1	Sample 2	Total Sample
Factor 1: self-efficacy				
9	I am confident I will do well on physics tests	0.59	0.66	0.63
14	I am confident I will do well on physics experiments	0.66	0.62	0.64
15	I believe I can master physics knowledge and skills	0.69	0.68	0.69
18	I believe I can get marks between 75% and 100% in physics tests and exams	0.60	0.58	0.59
21	I am sure I can understand physics	0.68	0.63	0.65
Factor 2: self-determination				
5	I put enough effort into learning physics	0.58	0.5	0.53
6	I use different strategies to learn physics	0.46	0.51	0.48
11	I spend a lot of time learning physics	0.50	0.56	0.54
16	I prepare well for physics tests and practicals	0.58	0.57	0.58
22	I study hard to learn physics	0.61	0.53	0.65
Factor 3: intrinsic motivation				
1	The physics I learn is relevant to my life	0.48	0.51	0.49
3	Learning physics is interesting	0.54	0.61	0.56
12	Learning physics makes my life more meaning full	0.55	0.60	0.58
17	I am curious about discoveries in physics	0.51	0.52	0.51
19	I enjoy learning physics	0.69	0.72	0.72
Factor 4: career motivation				
7	Learning physics will help me get a good job	0.68	0.66	0.66
10	Knowing physics will give me a job advantage.	0.74	0.72	0.73
13	Understanding physics will benefit me in my career	0.70	0.64	0.67
25	I will use physics problem solving skills in my career	0.52	0.43	0.49
23	My career or job will involve physics	–	–	–
Factor 5: goal motivation				
2	I like to do better than other students on physics tests	0.60	0.53	0.55
4	Getting a good science grade is important to me	0.56	0.62	0.58
8	It is important that I get marks between 75% and 100% in physics tests/exams	0.55	0.51	0.53
20	I think about the grade I will get in physics	0.47	0.49	0.48
24	Scoring high on physics tests and laboratory work matter to me a lot	0.55	0.53	0.55

Note: Item number 23 was removed.

Table 3. Tests of invariance of the physics version of SMQ-II across gender

	CFI	TLI	RMSEA	SRMR	ΔCFI
Girls	0.98	0.97	0.05	0.02	–
Boys	0.92	0.91	0.06	0.05	–
Configural invariance	0.95	0.94	0.06	0.03	–
Weak invariance	0.95	0.95	0.06	0.03	0.00
Strong invariance	0.96	0.95	0.06	0.03	0.01

Discussion

Adaptation and validation of an existing instrument enables cross-cultural comparisons and interpretation of results (Ardura & Pérez-Bitrián, 2018). We adapted and validated the SMQ-II using CFAs to

Table 4. Descriptive statistics of the physics version of the SMQ-II scales

Variable	Sex	*N*	Mean (SD)	*t*-Statistic	*p*-Value
Self-efficacy	Male	165	2.91 (0.86)	−0.60	0.55
	Female	209	2.96 (0.80)		
Self-determination	Male	165	2.71 (0.79)	−0.05	0.96
	Female	209	2.72 (0.73)		
Intrinsic motivation	Male	165	2.53 (0.91)	−0.29	0.77
	Female	209	2.55 (0.79)		
Career motivation	Male	165	2.93 (0.92)	−0.11	0.92
	Female	209	2.94 (0.89)		
Grade motivation	Male	165	3.12 (0.75)	−0.43	0.67
	Female	209	3.14 (0.72)		

Table 5. Descriptive statistics, correlations and reliability coefficients of the study variables

Variable	Mean (SD)	1	2	3	4	5	6	α
1. Interest	2.39 (0.80)	–	0.41**	0.50**	0.55**	0.41**	0.32**	0.74
2. Self-efficacy	2.94 (0.83)		–	0.56**	0.61**	0.62**	0.65**	0.78
3. Self-determination	2.72 (0.76)			–	0.61**	0.49**	0.53**	0.68
4. Intrinsic motivation	2.54 0(.84)				–	0.55**	0.53**	0.70
5. Career motivation	2.94 (0.90)					–	0.54**	0.72
6. Grade motivation	3.13 (0.73)						–	0.66

Table 6. Items and factor loadings for the Individual Interest Questionnaire before linear regressions using the whole selected sample

Item number	Item statement	Factor loadings
Prediction variable: individual interest		
1	I am very interested in physics	0.69
2	Outside of school, I read a lot about physics	0.60
3	I always look forward to my physics lessons	0.68
4	I am interested in physics since I was young	0.52
5	I watch a lot of physics related TV channels like discovery channel	0.44
6	Later in my life I want to pursue a career in physics or physics related discipline for example doctors, engineers, teachers	0.47
7	When I am reading something about physics or watching something about physics on TV, I am fully focused and at times I forget everything around me	0.41

test the five-component structure proposed by Glynn et al. (2011) and our findings provided evidence supporting the measure construct validity. The findings also confirmed fit for the Ugandan Physics version of the SMQ-II. This opens up the possibility of a reliable measurement of students' motivation to Physics learning within the Ugandan context and for reliable cross-cultural comparisons of the students' motivation.

Previous studies (e.g. Meece & Jones, 1996) have indicated a significant gender difference in students' motivation to learn science – with most studies reporting higher motivation for males. However, in our study there were no statistically significant differences obtained between gender for the components of motivation. Jaen and Baccay (2016) also noted no significant gender differences in

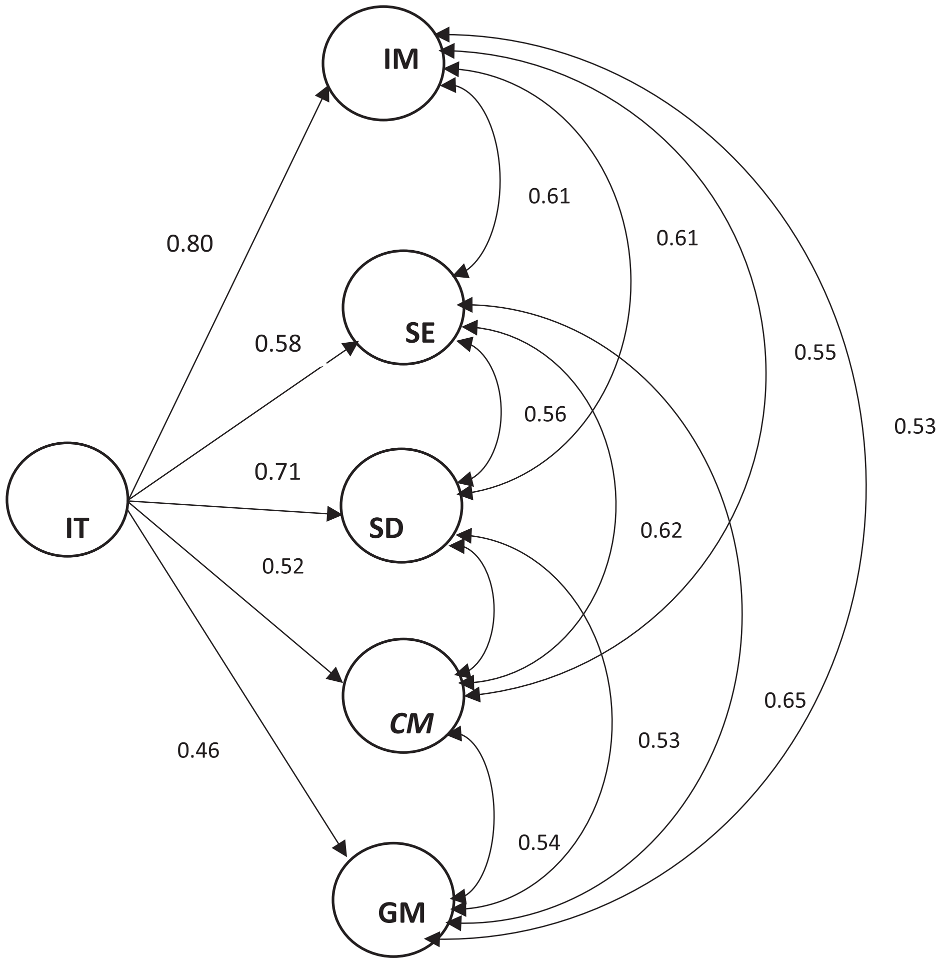

Figure 1. Regression model showing the weights of interest for each subscale of motivation. IT, Interest; IM, intrinsic motivation; SE, self-efficacy; SD, self-determination; CM, career motivation; GM, grade motivation.

students' motivation for mathematics learning. Our findings, in part, reveal that female secondary school students are equally motivated to learn Physics just like their male counterparts in lower secondary school in Uganda.

Interestingly, our analyses revealed that grade motivation was the most highly scored motivation trait, unlike intrinsic motivation, which scored the lowest. Findings using Greek (Salta & Koulougliotis, 2015), German (Schumm & Bogner, 2016) and Spanish (Ardura & Pérez-Bitrián, 2018) samples indicate a similar trend. For the Ugandan context, this finding is possibly an indicator that students may just want to pass the subject with relatively good grades. More so, the Ugandan Mathematics and Science curricula are overloaded with content. This poses major difficulties for teachers who resort to teacher-centred approaches (Opolot-Okurut, 2010) that emphasise motivation of their students towards obtaining higher grades (as indicated by the high scores of grade motivation). This extrinsic motivation towards grades has a detrimental effect on students' intrinsic motivation (see Potvin & Hasni, 2014).

Interest predicted students' motivation to learn Physics in Uganda. More specifically, interest explained more variance in intrinsic motivation and self-determination as compared with other motivational variables that we assessed. Our findings are in line with those of Bye et al. (2007). Usually, interest is the driving force behind intrinsic motivation (Schiefele, 1991), with a motivated student likely to display autonomy and employ self-initiated exploratory strategies (Schiefele, 1991), unlike uninterested students who rely on extrinsic motivation and instructions from the teachers as they seek external signs of work. Consequently, the uninterested learners cannot self-regulate their learning, which may result in low achievement in Physics.

Educational Implications

Since one of the postulated reasons for poor performance in Physics is the students' lack of motivation (González et al., 2017), there has been a lack of valid and reliable instruments to measure lower secondary school students' motivation to Physics learning. With our Physics version of the SMQ-II, other researchers in the region can adapt it to measure students' motivational traits and later if necessary design interventions that can result in improvement in Physics achievement. While taking into consideration suggestions made by Komperda et al. (2020), teachers and other researchers can use the instrument as a diagnostic tool after early identification of students' motivation levels.

Intrinsic motivation and self-determination were the lowest scores in our sample. Since self-determination is not usually taught in schools (Potvin & Hasni, 2014), it would be a wise decision for schools to shift from teacher-centred to student-oriented approaches during the teaching-learning process. This will provide support for learners' autonomy which in turn will increase their self-determination and regulation (Zamora & Ardura, 2014).

The role of interest in Physics learning has been clearly shown in our study. Interest does not only predict learner motivation to Physics learning, but also explains the variance in intrinsic motivation and self-determination. The low intrinsic motivation and self-determination in our sample is indicative of how low levels of interest among students impact their learning of Physics. To improve learners' motivation, it is important for teachers to trigger the learners' curiosity, enthusiasm and enjoyment, as well as support their autonomy. This can be done by use of teaching methods such as guided inquiry Science teaching that has been found to positively affect learners' interest (Wolf & Fraser, 2008) and in turn motivate them towards Science learning (see Kang & Keinonen, 2018; Ramnarain, 2014).

Limitations

First, questionnaires were used to collect data. Such self-report measures are prone to bias and social desirability (Rotgans, 2015). Future studies can employ a mixed-methods approach. Secondly, the SMQ-II had low reliabilities as compared with other studies we reviewed (see the section "The SMQ-II"). This could be due to the nature of the schools (semi-rural) we selected as compared with those used in the other studies we reviewed.

Conclusions

Firstly, the Physics version of the SMQ-II has been proven valid for lower secondary school students in Uganda. Therefore, this presents a valid instrument that can be used for measuring students' motivational traits to Physics learning. Secondly, there were no statistically significant relationships between gender and motivational levels towards Physics learning. Thirdly, lower secondary school students have low intrinsic motivation and high grade motivation. Lastly, interest predicts motivation to Physics learning. It is very important for educators to arouse the interest of learners if they are to improve on their motivation, and consequently their achievement in Physics.

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