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Creating an Enabling Environment for Learning Chemistry: A Case of Using Mobile Phone Apps for Attitude Change in Resource Constrained Private Secondary Schools in Uganda

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Abstract: *Intrigued by reports ranking chemistry as one of the worst performed science subjects over the years at Uganda Certificate of Examination level, citing attitude towards the subject as one of the explanations, this study investigated the effect of integrating WhatsApp supported instructional resources in the out of classroom teaching learning process on students' attitude towards the subject, as a possible intervention measure. The study used a mixed methods approach, taking on a quasi-experimental pretest –posttest none equivalent group design. The Solomon's Four Group design was specifically employed because of its high internal and external reliability and validity. Data from a sample of 240 student respondents, distributed between two experimental and two control schools was analyzed using the SPSS Independent and Paired samples t-tests for quantitative data, to establish whether there was a statistically significant difference between the experimental and control groups. Qualitative data was analyzed thematically, which was collaborated with the quantitative data. It was found out and later concluded that, the integration of WhatsApp supported instructional resources outside the classroom setting improved students' attitude towards chemistry with more students in experimental schools ranking the chemistry as one of the science subjects they liked most.*

Keywords: *WhatsApp, Mobile phone, Chemistry, Attitude, Teaching, Learning*

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1. Introduction

Chemistry is one of the core science subjects for most students aspiring to embark on different science courses in tertiary institutions (Yunus & Ali, 2012; Heng & Karpudewan, 2015). Excellent performance in chemistry therefore is a pre-condition for students to take on the subject at higher levels of the academic ladder (Komakech & Osuu, 2014; Uganda National Council for Science and Technology, 2012). Majority of students during their early years in secondary do hope to pursue science related careers in future as adults (Montes, et al., 2018).

Interestingly, many of the courses students point to at that early stage such as human and animal medicine, pharmacy, and nursing and engineering among others, require a student to have performed exceptionally well in chemistry at the upper secondary national examination in Uganda (Komakech & Osuu, 2014; Kabunga & Mohamed, 2018). A student is also expected to have performed exceptionally well in chemistry at the lower secondary national examinations to qualify for any subject combination with chemistry as one of the subjects of study (Kabunga & Mohamed, 2018).

Unfortunately, chemistry has always been reported as one of the worst performed science subjects at lower secondary national examinations (Uganda Certificate of Education) which has greatly suffocated the dreams of students to pursue science related careers (Musoke, 2015; Kabunga & Mohamed, 2018; Uganda National Council for Science and Technology, 2012). The challenge of poor performance in chemistry is not only identical to Ugandan students, as similar cases have been reported in other parts of the world (Ibrahim & Iksan, 2018; Jack, 2017; Khan & Ali, 2012; Montes et al., 2018; Yunus & Ali, 2018) Among other explanations to the poor performance, unfavorable students' attitude towards chemistry ranks high, more so in resource constrained schools (Yunus & Ali, 2018; Ogal, 2019; Musoke, 2015; Ibrahim & Iksan, 2018).

With a number of studies reporting that exploitation mobile phone apps cause a favorable attitude change in different contexts (Bensalem, 2018; Barhoumi, 2015; Aktas & Can, 2019; Hartnell-young & Heym,2008), this study sought to investigate if the WhatsApp App could be exploited to nurture a favorable attitude towards chemistry among lower secondary school students in resource constrained schools in Wakiso district -Uganda, given the increasing access to mobile phone technology by the general population in the country. This study therefore contributes to the ongoing debate about the possible intervention measures which could be explored to improve students' attitude towards learning science subjects and consequently better academic performance.

1.1 Theoretical Anchor

This study was informed by the social learning theory (SLT), put forward by Bandura (1962 cited Johnson & Bradbury, 2015). The theory states that learning occurs with in social context, facilitated by observation, imitation and modeling (Johnson & Bradbury, 2015; Frayne & Latham, 1987). The theory emphases learner attention, motivation, reproduction and retention as key components for learning to take place (Johnson & Bradbury, 2015). Theory also points to the importance of learning from others instead of solely relying on a person's own practices (Op cite). It also presupposes that behavioral and social competencies and cognitive skills are acquired through observational learning, where a person observes the modeled event and forms a cognitive construct, which later shapes the person's future behaviors (Devi, et al., 2017).

In relation to this study, it was presumed that through learners observing their peers as they interacted with their teachers by asking subject related questions, teachers providing feedback and forwarding illustrative chemistry instructional resources in a less restricted learning environment mediated by the mobile phone social networking apps, such as WhatsApp, even students with a negative attitude towards the subject could imitate the interaction behaviors of their peers and act in a similar way. As this behavior continues for some time, such students could come to realize that the subject is not as difficult as they thought once they productively interacted with their teachers, peers and the relevant supportive instructional resources

It was therefore assumed that students' attitude towards chemistry could be affected through students observing the instructional resources shared and imitating their peers' behavior via the mobile phones WhatsApp platform. This closely aligns well with the theory principals of observation, imitation and modeling. It was therefore anticipated that instructional resources in form of videos, photos, text, audios and visuals exchanged between teachers and their students as well as questions posed and responded to on the WhatsApp platform, could create an attractive enjoyable learning environment and hence cause a positive attitude change towards learning chemistry

1.2 Objective

To investigate the effect of integrating WhatsApp supported instructional resources in the out of classroom teaching-learning process on students' attitude towards Chemistry

1.3 Research Hypothesis

Integration of WhatsApp supported instructional resources in the out of classroom teaching-learning process improves students' attitude towards Chemistry

2. Literature review

Mobile phone Apps and Attitude

According to Kind, cited in Barmby, et. al (2008), attitude refers to the feelings that a person holds about an object, given the knowledge and belief about that object. Attitude consists of three key aspects, thus cognition feeling and behavior (Barmby, et. al, 2008). A person's knowledge and

beliefs about objects may give rise to an attitude about them, which may lead that person to behave in a specific way. In relation to chemistry as one of the study subjects in secondary schools, the acquired subject content by students during the classroom study process may influence them to develop a specific attitude towards the subject, and in turn may like or dislike the subject. This consequently could influence their motivation to learn the subject and hence academic performance.

A number of scholars (Bensalem, 2018; Barhoumi ,2015; Aktas & Can, 2019; Hartnell-young & Heym, 2008; Nundy, etal, 2014) have conducted studies on use of mobile phone apps to cause attitude change in different contexts. For example, in his study on comparison of use WhatsApp with the traditional means of teaching new vocabulary in English as a foreign language to Arab students, Bensalem (2018) studied a group of 40 university students split into experimental and control groups. It was found out that students who used WhatsApp outperformed their counterparts in a vocabulary test, and they exhibited a positive attitude towards learning new vocabulary items than their counter parts who used the traditional methods of learning.

Barhoumi (2015) conducted an experimental study, where he investigated the effectiveness of using mobile technologies to support blended learning. Sixty eight participants were engaged, equally split between experimental and control groups. The experimental group received in class instruction, supplemented with study resources and discussions via the WhatsApp platform yet the control group only received classroom instruction. The study findings revealed significant difference between the two groups in terms of attitude towards learning, with the experimental group exhibiting a favorable attitude compared to those who used the traditional methods of learning.

Using a mixed methods research approach, Aktas and Can (2019) carried out a study on sample of twenty students, aged between 15 and 16 year. The study aimed at establishing whether the use of WhatsApp actively in English outside the school had any effect on students' attitudes and self-efficacy belief in the English course. After eight weeks of the intervention, it was found out that the use of WhatsApp had a significant positive effect on students' attitudes and self-efficacy towards the English course.

A study was conducted by Hartnell-young and Heym, (2008) in the UK, aimed at establishing how mobile phones along with the respective Apps could be used to support learning in schools. A comparison of responses from teachers and students at the start and the end of project revealed a significant attitude change in favor of using mobile phones for learning. A similar study by Busulwa and Bbuye (2018) conducted in Uganda involving students, teachers and parents equally reported a positive change in attitude towards use of mobile phones and the associated Apps for learning. Tuysuz (2010) in a study to investigate the effect of the virtual laboratory on Students' achievement and attitude in Chemistry, study results revealed that virtual laboratory applications developed positive effects on students' achievements and attitudes towards chemistry which was not the case for traditional teaching methods.

Studies outside the education setting involving use of mobile phone Apps have reported a positive change in attitude among the respondents. For example, Nundy, et al. (2014) in their study on the effects of a Smartcare mobile phone App based intervention on diabetic patients at the University of Chicago Medicine in the USA, Sung & Cho (2012) in their study on immediate and delayed effects of different media types on respondents' attitudes towards mobile phone Apps aided advertisements; Wang et al., (2009) in their study about attitude change of drivers towards using mobile phones while driving, and Kroes & Shahid, (2013) in their study on empowering young adolescents to choose a healthy lifestyle using mobile phone interventions among other

However, while the above cited studies revealed a change in attitude with application of different Apps, none of the studies focused on use of Mobile phone WhatsApp App to nurture a favorable attitude towards learning chemistry, and specifically outside the classroom setting. In addition to this, related studies for example, Bensalem (2018); Barhoumi (2015); Aktas & Can (2019) among others were conducted outside the African setting and mainly focus on language learning. These gaps therefore justified the need for this study.

3. Methodology

3.1 Design

This study took a mixed research approach, involving collection of quantitative and qualitative data. Mixed methods research minimizes the limitations of relying on data collected using only one method (Creswell, 2014; Creswell, 2012; Wiersma & Jurs, 2004). A convergent parallel mixed method was employed and involved collection of both quantitative and qualitative data at roughly the same time. The collected data was integrated during the interpretation of the overall results (Creswell, 2014; Creswell, 2012; Wiersma & Jurs, 2004). A quasi-experimental pretest-posttest nonequivalent control group design was used, given that it is one of the most appropriate designs for studying nonrandomized subjects (Creswell, 2014; Wiersma & Jurs, 2004). Solomon Four Group design was specifically employed because it is highly recommended for achieving a higher internal and external validity in quasi experiments

3.2 Sampling strategy and sample size

Purposive, stratified and simple random sampling methods were used for this study. Purposive sampling was used for purposes of identifying the four day privately owned secondary schools located in different municipalities in Wakiso district, where students going to the different schools cannot easily come into contact. Stratified sampling was used to have equal representation male and female students to participate in the study and access to a smart mobile phone was one of the key inclusion criterions for experimental schools. After stratification of the student respondents, a simple random sampling technique was used to select students from each strata until the desired sample was achieved (Wiersma & Jurs, 2004; Wiersma, 2000;, Cohen, et al., 2007). A total of 244 respondents were sampled to participate in this study.

3.3 Instrumentation

A set of Self-administered questionnaire (SAQ) was administered twice, during the pretest and posttest phases. The SAQ question items were adapted from the Attitude Towards Chemistry Class Lessons Scale –ATCLS (Cheung, 2007 cited in Cheung, 2009), given the tool high internal consistency and reliability, with Cronbach's alpha of over 0.76. The tool has also been used by several scholars (Cheung, 2009;, Cheung, 2009b; Heng & Karpudewan, 2015; Khan & Ali, 2012) and partly recommended for its being precise and easy to administer (Khan & Ali, 2012). An interview guide was used twice, to collect the pre and posttest data.

3.4 Data Analysis

Quantitative data collected using the SAQ was analyzed using the Statistical Package for Social Scientists (SPSS) software version 25.0. Data analysis involved computation of both descriptive and inferential statistics. Descriptive statistics involved computation of frequencies, percentages, and means. For inferential statistics, the Independent sample t-test and a paired sample t-test were used to establish the degree of variance between groups. Qualitative data from interviews was analyzed thematically.

3.5 The intervention

Four chemistry teachers teaching in four different privately owned day schools with similar characteristics in Wakiso district were purposively sampled. Each of the teachers taught students in their respective schools during this study. Schools were randomly assigned to either experimental or control schools, giving rise to four schools, thus; two experimental schools (A and B) and two control schools (Xand Z).

A pretest SAQ was administered in the first week of the study in two schools; experimental school A and Control school Z. A pre-intervention interview was conducted as well on four students, two from each school. The purpose of the pretest was to determine the pre-intervention students' attitude towards chemistry and how they rated the subject against the other science subjects they studied at school.

In the second week, an agreed on topic of study in chemistry (Qualitative Analysis) was taught in three schools (experimental school A and B and Control school Z) in the normal classroom setting. Teaching was conducted theoretically (without any practical or visual demonstrations on use of the laboratory apparatuses or reagents). For experimental schools A and B, classroom teaching was supplemented with electronic chemistry instructional resources, about the topic which the teachers were handling. The e-materials were shared via the class WhatsApp platform, which was accessible to students on their mobile phones or their guardian's phones outside the classroom while at home.

For control school Z, there was no use of mobile phones; students only depended on the theoretical teaching and classroom notes given to them by their teacher in class. Students never received any supplementary electronic chemistry resources. At Control school X (pure control group), there was no any teaching about the topic of interest across the entire intervention period. The teacher just proceeded with normal coverage of the earlier on planed classwork.

At the end of the fourth week of the intervention in experimental schools, a posttest SAQ was administered in all the four schools, followed by interviewing of eight students. Figure 1 shows the summary of the experiment setup

E_A (S-79) ---------- **T_1** **X** **T_2**
E_B (S-57) ---------- -- **X** **T_2**
C_X (S-47) ---------- **T_1** ---- **T_2**
C_Z (S-57) ---------- ---- ---- **T_2**

Figure 1: Adapted Solomon's Four Group experimental setup

Where, E=Experimental Group C= Control Group
T1 = Pretest T2 = Posttest
X = WhatsApp supported chemistry e-instructional resources (Experimental Treatment)
S = Sample size

From Figure 1, posttest (T_2) results of groups E_A and C_x were compared to establish if there was a statistically significant difference in students' attitude towards

chemistry mean response scores between the two schools. The results were counter checked with comparison of posttest results of groups E_B and C_Z which never had a pretest.

A comparison of posttest results of Groups C_x and C_z was based on to establish if there was any testing effect on the study. These were counter checked with comparison of posttest results of groups E_A and E_B. This way, it was possible to rule out the major threats to internal and external validity in experimental studies

4. Results and Discussion

This study sought to test the research hypothesis stating; Integration of WhatsApp supported instructional resources in the out of classroom teaching-learning process improves students' attitude towards Chemistry. This sub-section therefore presents the results on the stated hypothesis.

Prior to running the parametric tests, data was tested for normality and the results are reflected in Figure 2.

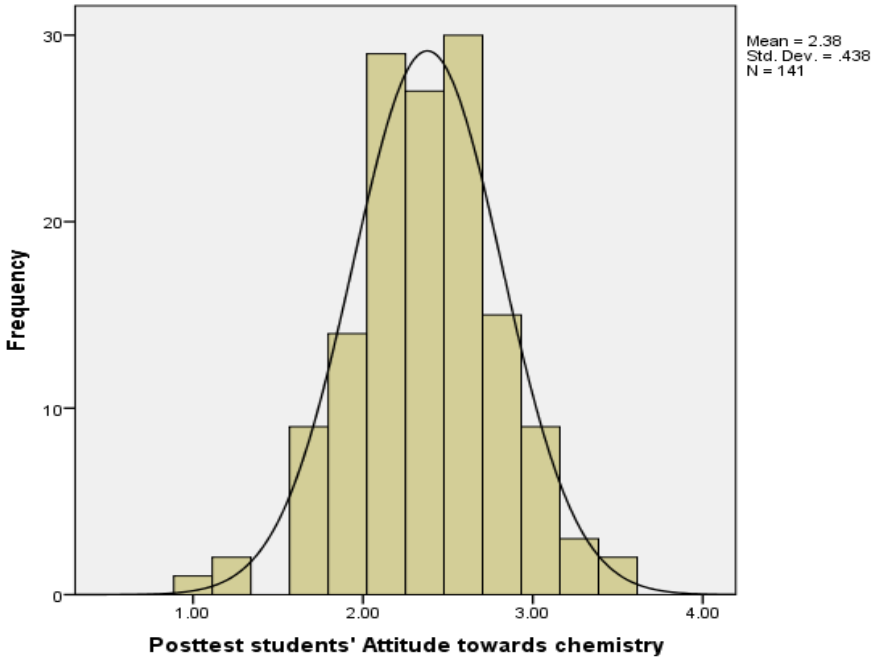

Figure 2: **Histogram for posttest students' Attitude towards Chemistry**

As reflected in Figure 2, data on students' posttest attitude towards chemistry was approximately normally distributed. It was therefore fit for parametric tests.

Sub-hypothesis H_{01}*.There's no statistically significant difference in students' pretest attitude towards chemistry mean response scores for Experimental school A and Control school X*

The purpose for testing the stated hypothesis was to establish if students from the two schools (Experimental school A and Control school X) were relatively at the same level, as regards students' attitude towards chemistry before the start of this study. Results are presented as in Table 1

Table1: Independent Sample t-Test for students' attitude towards chemistry mean response scores for Experimental school A and Control school X

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Pretest students' Attitude	Equal variances assumed	5.248	.024	1.100	111	.274
	Equal variances not assumed			1.050	80.345	.297

Table 1 shows that, the computed Independent sample t-test revealed no statistically significant difference in students' attitude towards chemistry mean response scores between experimental school A and Control school X (sig. 2-tailed 0.297). The computed r^2= 0.00 also shows a very small difference effect, hence accepting the Null hypothesis; *H_{01}.There's no statistically significant difference in students' pretest attitude towards chemistry mean response scores for Experimental school A and Control school X*. This implies that both schools (Experimental school A; M= 2.560 and Control school X; M=2.478) held almost the same attitude towards chemistry.

Sub-hypothesis *H_{02}.There's no statistically significant difference in students' posttest attitude towards chemistry mean response scores for Experimental school A and Control school X*

The purpose for this hypothesis was to investigate the effect of the study intervention. Results are presented in table 2.

Table 2: Posttest Independent Sample t-Test for students' Attitude towards chemistry Mean response scores for Experimental school A and Control school X

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Posttest students' Attitude	Equal variances assumed	5.591	.021	-8.485	78	.000
	Equal variances not assumed			-9.123	77.578	.000

The computed Independent sample t-test (sig. 2-tailed 0.000) shows a statistically significant difference in students' attitude towards chemistry mean response scores between the two schools as shown in table 2. The computed r^2= 0.51, also shows a very large difference effect, hence rejecting the Null hypothesis; *H_{02}: There's no statistically significant difference in students' posttest attitude towards chemistry mean response scores for Experimental school A and Control school X*

Given that the students' attitude towards chemistry were almost the same during the pretest phase, then the significant difference between the two schools during the posttest can be attributed to the study intervention of using the mobile phone WhatsApp supported instructional resources in experimental school A with a favorable mean score (M=1.77) unlike control school X (M=2.53) where mobile phones were not used, basing on the on the four point Likert scale used to collect the data (1=Strongly agree, 2=Agree, 3=Disagree, 4= Strongly disagree).

Sub-Hypothesis *H_{03}.There's no statistically significant difference in students' posttest attitude towards chemistry mean response scores for Experimental school B and Control school Z*

The purpose for testing the stated hypothesis was to further investigate the effect of the intervention. The results were also used to investigate if there were any testing effects in the posttest results of the study. Results are presented in Table 3.

Table 3: Independent Samples Test for Posttest students' attitude towards chemistry mean response scores for Experimental school B and Control school Z

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Posttest students' Att.	Equal variances assumed	6.084	.016	-5.721	89	.000
	Equal variances not assumed			-5.802	78.772	.000

Table 3 shows that, there was a statistically significant difference (sig. 2-tailed 0.000) in students' attitude towards chemistry mean response scores between Experimental school B and Control school Z. The computed r^2=0.27 also pointed to a very large difference effect, hence rejecting the Null hypothesis; *H_{03}. There's no*

statistically significant difference in students' posttest attitude towards chemistry mean response scores for Experimental school B and Control school Z

Since the computed mean response score for experimental school B (M=1.89) indicated a better attitude compared to control school Z (M=2.38), it reaffirms that the use of mobile phone WhatsApp supported instructional resources contributed to an improvement in students' attitude towards chemistry for Experimental school B. Secondly, given that both schools never participated in the pretest, yet these results are comparable to schools which had a pretest (experimental school A and control school Z), it rules out any testing effects in the study.

Sub-Hypothesis*: H_{04} There's no statistically significant difference in students' posttest attitude towards chemistry mean response scores for Control school X and Control school Z*
Testing this hypothesis was intended to further investigate for any testing effects in the study. Results are presented in table 4.

Table 4: Independent Sample t-Test for Posttest students' attitude towards chemistry mean scores for Control school X and Control school Z

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Posttest Students' Attitude	Equal variances assumed	5.527	.021	1.335	76	.186
	Equal variances not assumed			1.459	75.907	.149

Results as shown in Table 4, reveal that there was no statistically significant difference (sig. 2-tailed = 0.149) between the two schools, as regards students' attitude towards chemistry. The computed r^2=0.02 points to a very small difference effect, hence accepting the Null hypothesis: *H_{04}. There's no statistically significant difference in students' posttest attitude towards chemistry mean response scores for Control school X and Control school Z.* Since control school X took part in the pretest unlike control school Z, but both schools had almost the same results (M=2.51 and M=2.38; means for school X and Z respectively) this confirms that there were no testing effects in the posttest results.
Qualitative data from interviews was largely in agreement with the quantitative data so far presented. In the pretest phase, three out of the four interviewed respondents never mentioned chemistry as one of their favorable science subjects. For example, respondent EA_1 said that:
"… Physics is my best subject, because I find it easy. ..It is easy for me partly because our teacher gives us enough time. He is friendly and approachable whenever I have any challenges……". When asked further to rank all the science subjects in their order of liking, the student ranked chemistry as the least liked subject.

However, during the posttest interview, majority of the respondents in experimental schools ranked chemistry high as one of the subjects they liked, which was not the case for control schools. For example, respondent EA_4 explained that; *"Chemistry is my best science subject…what makes it simple is that the teacher tries his best to make us pick what he is teaching. He even sends us videos on the class WhatsApp group explaining more about what he taught. …even in the group he sends us questions that help us learn from each other…"*

Previous studies conducted on attitude in different context are largely consistent with this study's findings. For example, Bensalem (2018) conducted a study in which a comparison was made on use of WhatsApp and other traditional means of learning new vocabulary in English Language among Arab students. It was reported that students who used WhatsApp performed better than their counterparts who used the traditional means, and manifested more positive attitudes towards learning new vocabulary items. Study findings of Barhoumi (2015), Aktas & Can (2019), Hartnell-young & Heym, (2008), Tuysuz (2010), Nundy, et al. (2014), Sung & Cho (2012), Wang et al., (2009), Kroes & Shahid, (2013)among others were as well consistent with this study results. However, Sung & Cho (2012) in their study reported that sometimes the attitude change is short-lived, that in the long-run, some respondents' attitude again shifted back. In relation to this study, an investigation covering relatively a longer period of time would be exciting to conduct, to find out if the attitude change can be sustained for long period of time.

5. Conclusion and Recommendations

This study concluded that integration of WhatsApp supported instructional resources in the out of classroom teaching learning process improves students' attitude

towards chemistry. The opportunity mobile phones social networking Apps such as WhatsApp creates room for learners to interact with not only their teachers and peers, but with study materials as well, presented in slightly a different format, all of which work to modify the learners' attitude towards the subject and hence learning.

Basing on this study results, the following recommendations are made;

i) There is need for teachers more so the chemistry and science teachers, to developed strategic tactics and make efforts towards cultivating a positive attitude among their students towards their subject areas for better academic achievement rather than simply acknowledging the existence of students with a negative attitude towards their subjects

ii) There is need for school authorities to devise alternative ways of safely allowing students to carry mobile phones at schools, as the advantages could outweigh the associated disadvantages

Limitation

The study was conducted during the Covid-19 period. This caused restrictions on teacher movement between schools. The initial teaching approach was to have only two teachers involved in the study, to teach in two schools each (one experimental and one control school). This purpose was to control the teacher related characteristics which could impact on the quality of teaching and teacher students' interactions which were key variables that might have affected this study results. Secondly, the study was restricted to only one month and a half. There was need to investigate if the positive change in students' attitude towards chemistry in experimental schools could be sustained for a fairly long period of time, such as a year or two.

Compliance with ethical standards

Consent was sought for from student respondents along with their parents, since majority were minors. Teacher participants consented in person to participate in the study.

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