The role of age, gender, experience, education and professional registration in acceptance of QGIS in South Africa

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Abstract

The benefits of free and open-source software for geographical information systems (FOSSGIS), such as QGIS, are appreciated by many all over the world. However, QGIS adoption in South Africa is not primarily influenced by the benefits attributed to open-source software, such as cost benefits, customizability, improved reliability, quality and security. In the first paper from this study, it was found that habit, followed by facilitating conditions, price value and social influence, had the greatest influence on the behavioural intention of members from South Africa's geospatial community to use QGIS. In this paper, several hypotheses were developed and tested to investigate the role that moderators (age, gender, GIS experience, educational level and registration with the South African Geomatics Council) had on the behavioural intention of geospatial practitioners in South Africa to use QGIS. Results show that GIS experience, educational level and registration with the South African professional body for geomatics practitioners had a moderation effect on some of the hypothesized relationships, while age and gender did not have any significant effect. Results also show that as one gains experience, social influence and facilitating conditions are less important when deciding to use QGIS; a postgraduate education and professional registration increase appreciation for getting value for money; and registered professionals are not significantly influenced by the perceptions of others when deciding to use QGIS. Habit is not influenced by any of the moderators, suggesting that breaking the habit of using a particular product is a challenge regardless of age, gender, experience, education level or registration status. These results are useful for developers of any GIS product and for choosing a GIS product for an organization, because

they explain which user characteristics influence behavioural intention to use a specific GIS product.

Keywords
QGIS, FOSSGIS, technology acceptance, UTAUT2, moderators, South Africa

1. Introduction

Free and open source for geographical information system (FOSSGIS) tools, such as QGIS and GRASS, provide the same benefits attributed to open source software, such as cost benefits, customizability, improved reliability, quality and security (Steiniger and Hay, 2009). FOSSGIS uptake is on the rise globally, evident from the increase in research and applications involving FOSSGIS tools and the growing numbers of attendants at the yearly FOSS4G international conference (OSGeo, 2020b), the annual global conference for open source geospatial software (OSGeo, 2020a). QGIS is an OSGEO project. OSGEO is an international non-profit organization promoting open source for geospatial (QGIS, 2021).

While most FOSSGIS activity originates from North America and Europe, Quinn (2020) reports that there is substantial FOSSGIS adoption by some South American governments, albeit to a different set of reasons than those observed in the Global North. South Africa has a policy promoting the use of FOSS in government (South Africa, 2006), but its importance is uncertain (Meintjies, 2018, Henrico et al., 2021). This policy states that FOSS will be implemented in South Africa, “unless proprietary software is demonstrated to be significantly superior”. It further states that new software developments will use open standards that adhere to FOSS principles and will have a FOSS license (South Africa, 2006). However, in the likes of the OSGeo Africa mailing lists, concerns get raised over tenders for proprietary software that seem to contravene this policy, e.g. Fleming (11 September 2019), and Newmarch (11 September 2019); but it is only a policy, not the law. Hence, it is not surprising that the acceptance of FOSSGIS in South Africa does not happen at the same rate as it does in other countries. On the other hand, procurement processes are a barrier to acquiring proprietary software. A questionnaire distributed to the geoinformation community of South Africa revealed that only about 20% of respondents frequently used an open-source desktop GIS product and just over 10% of them frequently used a custom-built platform based on open source software. The corresponding responses for proprietary software were 45% and 25% respectively (Coetzee, 2016; Coetzee et al., 2014).

For this study we adapted the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) (Venkatesh et al., 2012) to test the effect of constructs and moderators on the behavioural intention of geospatial practitioners in South Africa to use QGIS. The UTAUT2 model is widely used in technology acceptance studies (Henrico et al., 2021), specifically for desktop software (Algharibi and Arvanitis, 2011; Marchewka and Kostiwa, 2007; Sharma and Kumar, 2012). Tamilmani et al. (2021) conducted a review of all papers through to March 2017 that referenced Venkatesh et al. (2012), the paper that introduced UTAUT2. Of the 650 they could access, they found that 503 (77%) were general citations (i.e. did not use the theory significantly), while 24 applied UTAUT2, 57 integrated UTAUT2 with other theories and 66 extended UTAUT2 (Tamilmani et al., 2021). For our research, we extended UTAUT2.

In the first set of results from this study (Henrico et al., 2021), we reported that habit had the most significant effect on the behavioural intention to use QGIS, followed by facilitating conditions, price value and social influence. Performance expectancy, effort expectancy, hedonic motivation and access to source code played no significant role (see Table 1 for definitions). This implies that users who have never used QGIS, are also unlikely to use it in future because of their habits. Therefore it is important to understand which variables influence the relationship between behavioural intention and UTAUT2 constructs, such as habit and facilitating conditions.

In this paper, we report further results from the study. We evaluated the hypotheses that the relationship between behavioural intention and a second variable (for example habit or facilitating conditions) is moderated by a third variable (such as age, gender or GIS experience). This third variable is referred to as a moderator (Aguinis, 2004). Moderators can make the relationship between dependant and independent variables stronger or weaker (Alshehri, 2012). In sophisticated technology acceptance models, such as the UTAUT2 model, it is common practice to examine the effect that moderators have on the various constructs of the model (Khan et al., 2017; Ally and Gardiner, 2012; Chang et al., 2019; Beh et al., 2019). In other studies, related to the UTAUT2 model, some interesting moderation effects were observed (Gallego and Bueno, 2010; Venkatesh et al., 2003). For example, Gallego and Bueno (2010) found that user experience is an important demographic dimension when describing acceptance of FOSS. The results of these moderating effects differ depending on which technology is tested. Results can also vary in different areas or countries (Attuquayefio and Addo, 2014).

The outline for the paper is as follows: in section 2, the research model and related hypotheses are presented; in section 3 the method followed is discussed; in section 4 the data analysis and results follow; and section 5 discusses the results and concludes.

2. Research model and hypotheses

2.1 The UTAUT2 model adapted for this study

The importance of understanding acceptance among a wide variety of technologies is of such importance when reviewing the usefulness of that technology that it has been elaborately researched over many years (Henrico et al., 2021). The extended unified theory of the use and acceptance of technology (UTAUT2) combined and reinforced all prior research and showed an improved variance in behavioural intention and technology use (Venkatesh et al., 2003). The constructs of the adapted model are shown in Table 1.

Table 1. Constructs in the adapted UTAUT2 model

Construct	**Definition**
Performance Expectancy (PE)	"the degree to which a person believes that a particular system will help to attain advances in job performance" (Venkatesh et al., 2016)
Effort Expectancy (EE) (Ameen and Willis, 2018)	"the degree of ease associated with consumers' use of technology"(Venkatesh et al., 2012)
Social Influence (SI) (Chang et al., 2019)	"the degree to which an individual perceived that important others believe he or she should use the new system" (Venkatesh et al., 2003)
Hedonic Motivation (HM)	"the fun or pleasure derived from using a technology, and it has been shown to play an important role in determining technology acceptance and use" (Venkatesh et al., 2012)
Price Value (PV)	"consumers' cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012)
Habit (H)	"the extent to which people tend to perform behaviours automatically because of learning" (Venkatesh et al., 2012)
Facilitating Conditions (FC)	"the consumers' perception of available support when using the consumer system" (Venkatesh et al., 2016)
Behavioural Intention (BI)	"the individual willingness to use and continue to use a technology, and the factor that determines the usage of a technology" (Miladinovic and Hong, 2016)
Source Code (SC)	the ability to use, share, develop and contribute source code to the software" (Henrico, 2020)
Software Support (SS)	the availability of technical support for the products (Henrico, 2020)

The aim of this paper is to present the results of the hypothesized effects of moderators on the relationships between the dependent variable (behavioural intention) and the independent variables are (PE, EE, SI, HM, PV, H, FC, SC and SS). The original UTAUT2 model was adapted by adding

two additional constructs, namely: software support and source code. The three moderators included in the UTAUT2 model - age, gender and experience - were tested, as well as two additional moderators – educational level and professional registration with the South African Geomatics Council (SAGC) – introduced for this study specifically. The hypothesized effects of moderators in this study, based on the constructs and moderators above are illustrated in Figure 1.

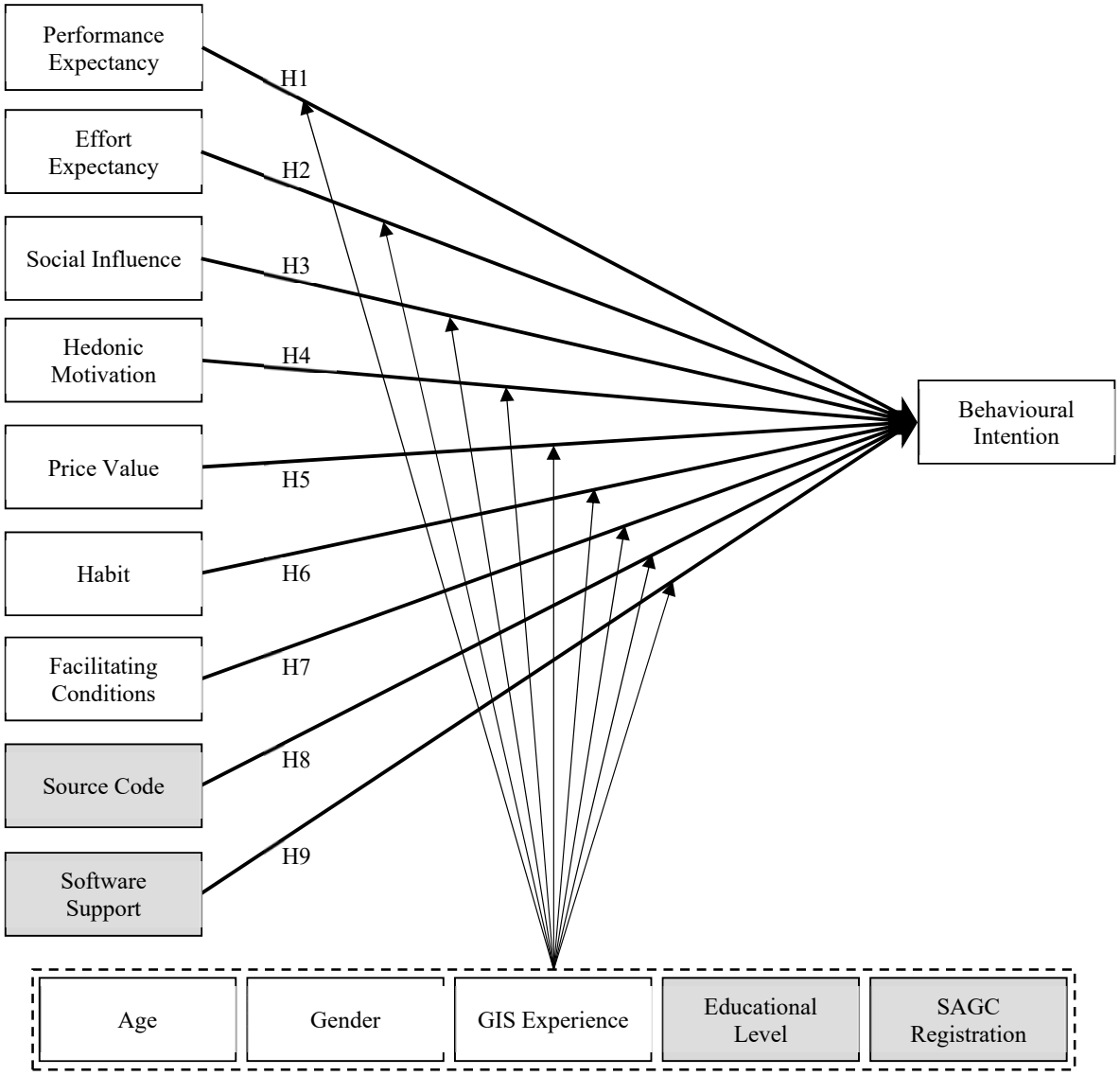

Figure 1. Hypotheses for this study, adapted from UTAUT2 in Venkatesh et al. (2012). Additional constructs and moderators are shaded in grey. (Source: Henrico et al. 2021)

2.2 Age

Venkatesh et al. (2003) incorporated age as a moderator in the UTAUT2 model. In some technology acceptance studies, younger people significantly influenced older people to adopt a new technology. In these studies, younger people were seen as both 'early adopters' and 'influencers'

(Mallenius et al., 2007). In the study by Gallego and Bueno (2010), it was found that age played a significant role in information system acceptance. The moderating effect of age on all the constructs of the research model was therefore tested. The questionnaire included the following categories: 18 – 30 years, 31 – 60 years, and 61 – 80 years.

H10: Age will moderate the effect of PE, EE, SI, HM, PV, H, FC, SC and SS on a user's behavioural intention to use QGIS.

2.3 Gender

Venkatesh et al. (2003) introduced gender as one of the moderating variables in order to allow for heterogeneity in observations. According to Cinco (2010), in countries where well-established, 'robust' FOSS communities exist, "it is clear that FOSS is a male-dominated environment". Among the members of OSGeo there have been lengthy debates about gender bias and representation (OSGeo, 2021). We wanted to investigate if gender had a moderating effect on any of the tested variables.

H11: Gender will moderate the effect of PE, EE, SI, HM, PV, H, FC, SC and SS on a user's behavioural intention to use QGIS.

2.4 GIS Experience

In the study by Venkatesh et al. (2003), it was found that users with lower levels of experience favoured technologies that require less effort and that these users were more influenced by others socially. Venkatesh et al. (2003) also noted that people with less experience paid less consideration to facilitating conditions. In other FOSS user acceptance studies, it was found that user experience was an important demographic consideration (Gallego and Bueno, 2010). It is therefore necessary to investigate the possible moderating effect that experience with GIS software, either as practitioner or as educator, can have on the other constructs of the research model.

H12: GIS experience will moderate the effect of PE, EE, SI, HM, PV, H, FC, SC and SS on a user's behavioural intention to use QGIS.

2.5 Educational level

This moderator measures the respondent's education level, and is an important factor in predicting the acceptance of technology by users (Abu-Shanab, 2011), confirmed by Binyamin et al. (2019), who found a positive relationship between educational level and the use of technologies. We

therefore wanted to understand whether users with higher education levels would consider using both proprietary and open source GIS. It is for these reasons that educational level was added as a moderator when testing the acceptance and use of QGIS.

H13: Educational level will moderate the effect of PE, EE, SI, HM, PV, H, FC, SC and SS on a user's behavioural intention to use QGIS.

2.6 SAGC Registration

According to Kim (2009), professionalism, which is an individual factor trait, is an important determining factor for the acceptance of information technology. In South Africa, many people working in the geospatial industry are registered with a statutory professional body, e.g. surveyors and geographic information science (GISc) practitioners register with the South African Geomatics Council (SAGC), natural scientists with the South African Council for Natural Scientific Professions (SACNASP) and planners with the South African Council for Planners (SACPLAN). Since most people in the GISc community in South Africa are registered with the SAGC (Coetzee et al., 2014), professional registration with SAGC was included as a moderator in the UTAUT2 model adapted for this study.

H14: SAGC registration will moderate the effect of PE, EE, SI, HM, PV, H, FC, SC and SS on a user's behavioural intention to use QGIS.

3. Method

3.1 Participants

The data was collected from the members of the Geo-Information Society of South Africa (GISSA) to investigate which factors have a significant influence on the behavioural intention of South African geospatial professionals to use QGIS. A questionnaire based on the adapted UTAUT2 model was handed out to GISSA members at the national and several regional GISSA meetings in 2019. More than half of these members (65.4%) were also registered with the South Africa Geomatics Council (SAGC), the professional body for geomatics practitioners, which implies that they have completed at least three years of tertiary education related to the geospatial field (see Table 2). The SAGC provides professional registration in various branches, including GISc, land, engineering and mining surveying. Members can apply for registration in one of four categories, which are ranked from lowest to highest, based on their level of education and training: Candidate, Technician, Technologist and Professional (SAGC, 2020).

Table 2. Characteristics of participants (n=205)

Category	Characteristic	Frequency	Percentage	Gender			
				Male		Female	
				(n)	(%)	(n)	(%)
Total participants				112	54.6	93	45.4
Age	18 – 30 years	48	23.4	26	23.2	22	23.4
	31 – 60 years	149	72.7	79	70.5	70	75.3
	61 – 80 years	8	3.9	7	6.3	1	1.1
Years of experience with GIS	Between 0 – 5 years	57	27.8	29	25.9	28	30.1
	More than 5 – 10 years	42	20.5	23	20.5	19	20.4
	More than 10 – 15 years	41	20.0	17	15.2	25	25.8
	More than 15 – 20 years	27	13.2	12	10.7	15	16.1
	More than 20 years	38	18.5	31	27.7	7	7.5
Years of experience with QGIS	No experience with QGIS	65	31.7	30	26.8	35	37.6
	1 year	38	18.5	20	17.9	18	19.4
	2 years	32	15.6	17	15.2	15	16.1
	Between 3 – 5 years	46	22.4	28	25	18	19.4
	Between 5 – 10 years	17	8.3	11	9.8	6	6.5
	More than 10 years	7	3.4	6	5.4	1	1.1
Educational level	GIS courses at various institutions	14	6.8	8	7.1	6	6.5
	National Certificate	10	4.9	5	4.5	5	5.4
	National Diploma	38	18.5	17	15.2	21	22.6
	Degree	45	22.0	23	20.5	22	23.7
	Honours/4-year degree	53	25.9	29	25.9	24	25.8
	Masters	37	18.0	23	20.5	14	15.1
	PhD	8	3.9	7	6.3	1	1.1
SAGC registration	Yes	134	65.4	68	60.7	66	71
	No	71	34.6	44	39.3	27	29
SAGC registration category	Candidate	7	3.4	6	8.8	1	5.2
	Technician	56	27.3	22	32.4	34	51.5
	Technologist	18	8.8	7	10.3	11	16.7
	Professional	53	25.9	33	48.5	20	30.3

3.2 Measure

A cross-sectional study was conducted, using a questionnaire handed out at the various GISSA meetings in 2019 and we received 295 responses. Of these, 205 responses were deemed valid, i.e. all questions were answered. We followed the 'complete case approach' for questionnaires with missing values (Hair et al., 2006). While the sample may appear small, it reflects a reasonably high response rate in 2019, there were 712 active, registered GISSA members, with a split of about 45% female and 55% male. This correlates well with the ratios for this study shown in Table 2. While our sample has a representative ratio, we do not know whether the women who responded are different in some important way from other women in GIS-related fields who are not members of GISSA. However, our study only focuses only on GISSA members, for which we have a representative sample and ratio. The questionnaire consisted of two main parts, the demographic questions and the questions relating to the various constructs.

The aim of moderator analysis is to establish whether the relationship between two variables (for example X and Y) "is moderated by" a third variable (see Figure 2). This third variable is referred to as the moderator, i.e. due to the effect of a moderator, there is a weaker or stronger relationship between the dependant and independent variables (Alshehri, 2012).

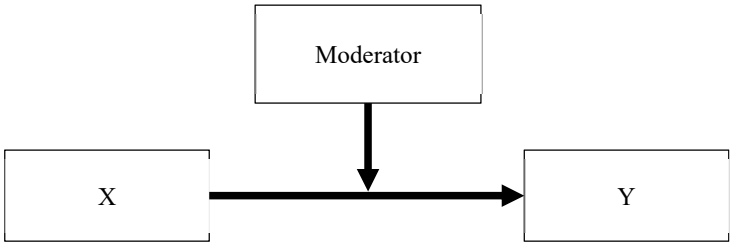

Figure 2. Representation of a Variable Serving as a Moderator (Aguinis, 2004)

In this study, the addition of an (linear) interaction term in a multiple regression model was used to determine whether a moderating effect exists (Aguinis, 2004). This standard method is often referred to as moderated multiple regression (MMR). Independent evaluations proved that this standard method is suitable for testing moderation (Aguinis, 2004). Reliability and validity testing, and the MMR, were executed in IBM SPSS Statistics for Windows, Version 25.0.

In order to know whether there is a moderator effect, one needs to inspect the change in R^2 (for Model 2 – the model where the interaction term was introduced) (Aguinis, 2004) to determine the statistical significance of the interaction term, i.e. whether the effect of an independent variable (PE, EE, SI, HM, PV, H, FC or SC) on the dependant variable (behavioural intention) is influenced by a moderator (Binyamin et al., 2019). The change in R^2 therefore represents the increase in variation explained and therefore indicates whether the change was statistically significant when the interaction term (Model 2 – the model with the moderator) was introduced to Model 1 (the model without the moderator. Variables were hence inspected to see whether critical ratios for the differences in parameters exceed the significance thresholds of $t > 1.96$ and $p < 0.05$ (Aguinis, 2004). The hypothesis for each moderation relationship is explained in more detail in the subsections that follow.

3.3 Research ethics

Ethical considerations are vital during any research process to ensure that human rights are not violated and also to enhance a scientific approach to research. In this study, human participants were used to complete questionnaires and to participate in interviews. Ethical approval (reference

number: HUM 018/0119) for this study was obtained from the University of Pretoria's Research Ethics Committee. All participants were also duly informed of their rights and that participation in the study was voluntary and anonymous. Participants were also informed of their right to withdraw at any stage of the study. A consent form was signed by all participants.

4. Data analysis and results

In this section, results of the moderation analysis are presented. Both age and gender had no significant effect on the relationship between any of the variables of the adapted UTAUT2 model and behavioural intention. Age and gender will therefore be discussed together. The other three moderators had a moderating effect on some of the hypothesized relationships and will be discussed one by one. For each moderator, the variables were inspected to see whether critical ratios for the differences in parameters exceeded the $t > 1.96$ threshold and whether $p < 0.05$.

4.1 The effect of age and gender

The analysis of the effect of age on the different variables is summarised in Table 3. For the moderation analysis of the age variable, the respondents were divided into two groups: younger and older users. Respondents that were 30 years and younger were included in the "younger" group, while respondents older than 30 years were assigned to the "older" group. The results of the analysis of the MMR indicate that the overall regression was not significant. Therefore, age does not significantly moderate any of the variables (i.e. H10 is not supported). Further disaggregation of the age groups was not possible.

Table 3. Simultaneous Analysis of Age

Parameter			t - value		Result
			Younger Users	Older Users	
PE	→	BI	1.817	1.262	Not significant
EE	→	BI	-.568	-.925	Not significant
SI	→	BI	1.321	.895	Not significant
HM	→	BI	.522	.684	Not significant
PV	→	BI	.115	.012	Not significant
H	→	BI	-.596	-.754	Not significant
FC	→	BI	.050	-.001	Not significant
SC	→	BI	.050	-.001	Not significant

For the moderation analysis of the gender variable (see Table 4), the respondents were divided into two groups: male and female. The results of the analysis of the MMR indicate that the overall

regression was not significant. Therefore, gender does not significantly moderate any of the variables (i.e. H11 is not supported).

Table 4. Simultaneous Analysis of Gender

Parameter	t - value	Result
	Gender	
PE → BI	-1.210	Not significant
EE → BI	.557	Not significant
SI → BI	1.949	Not significant
HM → BI	-.334	Not significant
PV → BI	-.595	Not significant
H → BI	1.026	Not significant
FC → BI	-1.000	Not significant
SC → BI	.308	Not significant

4.2 The effect of GIS experience

The analysis of the effect of GIS experience on the different variables is summarised in Table 5. For the moderation analysis of the GIS experience variable, the respondents were divided into four groups: between 0 – 5 years, between 5 – 10 years, between 10 – 15 years and between 15 – 20 years.

The analysis of the MMR results (see Table 5), indicated that the overall regression was not significant for the following variables: PE, EE, HM, PV, H, and SC.

Table 5. Simultaneous Analysis of GIS Experience (grey shading indicates significant moderation effect)

Parameter	t - value				Result
	0 – 5 Years	5 – 10 Years	10 - 15 Years	15 – 20 Years	
PE → BI	.154	1.377	-.668	-.610	Not significant
EE → BI	-.332	1.220	.943	.825	Not significant
SI → BI	1.120	2.257	1.334	.205	Significant
HM → BI	-1.399	-.454	.524	-.432	Not significant
PV → BI	-1.812	-.763	.570	-.366	Not significant
H → BI	-1.607	.511	-.978	-1.025	Not significant
FC → BI	1.098	1.955	2.114	-.079	Significant
SC → BI	-.657	-.315	-.128	-1.879	Not significant

However, GIS experience significantly influenced (moderated) the effect of social influence on behavioural intention, as seen from the analysis of the MMR results. The change in R^2 was 2.4%. This increase is statistically significant (t = 2.257, p = .025 and therefore, p < .05). Note also that the relationship between social influence and behavioural intention varied significantly between GIS experience groups (see Table 5). This relationship (between social influence and behavioural intention) was only statistically significant and notably stronger for the experience group, "between 5 – 10 years". The interactive effect for this group was positive (b = 0.502) which means that with the introduction of this interaction term, the effect of SI on BI became stronger.

GIS experience also significantly influenced (moderated) the effect of facilitating conditions on behavioural intention, seen from the analysis of the MMR results. The change in R^2 was 3.5%. This increase is statistically significant (t = 2.114, p = .036 and therefore, p < .05). Note also that the relationship between facilitating conditions and behavioural intention varied significantly between GIS experience groups. This relationship (between facilitating conditions and behavioural intention) was only statistically significant and notably stronger for the experience group, "between 10 – 15 years". The interactive effect for this group was positive (b = 0.425) which means that with the introduction of this interaction term, the effect of FC on BI became stronger.

4.3 The effect of educational level

The analysis of the effect of the educational level on the different variables is summarised in Table 6, which shows the t-values for those with at least a four-year university degree (referred to as postgraduate).

Table 6. Simultaneous Analysis of Educational Level (grey shading indicates significant moderation effect)

Parameter			t - value	Result
			Postgraduate	
PE	→	BI	.921	Not significant
EE	→	BI	1.339.	Not significant
SI	→	BI	1.517	Not significant
HM	→	BI	.200	Not significant
PV	→	BI	2.728	Significant
H	→	BI	.402	Not significant
FC	→	BI	.316	Not significant
SC	→	BI	.543	Not significant

The analysis of the MMR results (see Table 6), indicated that the overall regression was not significant for the following variables: PE, EE, SI, HM, H, FC and SC.

However, educational level significantly influenced (moderated) the effect of price value on behavioural intention as seen from the analysis of the MMR results. The change in R^2 was 3.2%. This increase is statistically significant (t = 2.728, p = .007 and therefore, p < .05). The interactive effect for this group was positive (b = 0.360), which means that with the introduction of this interaction term, the effect of PV on BI became stronger (i.e., when the educational level increased, the effect of PV on BI became stronger).

4.4 The effect of SAGC registration

The analysis of the effect of SAGC registration on the different variables is summarised in Table 7. For the moderation analysis of the SAGC registration variable, the respondents were divided into two groups: registered and not registered.

The analysis of the MMR results (see Table 7), indicated that the overall regression was not significant for the following variables: PE, EE, HM, H, FC and SC.

Table 7. Simultaneous Analysis of SAGC Registration (grey shading indicates significant moderation effect)

Parameter			t - value	Result
			Registration	
PE	→	BI	.886	Not significant
EE	→	BI	.537	Not significant
SI	→	BI	-2.144	Significant
HM	→	BI	1.271	Not significant
PV	→	BI	2.115	Significant
H	→	BI	-1.459	Not significant
FC	→	BI	-1.593	Not significant
SC	→	BI	-.642	Not significant

SAGC registration significantly influenced (moderated) the effect of social influence on behavioural intention as seen from the analysis of the MMR results. The change in R^2 was 1.9%. This increase is statistically significant (t = -2.144, p = .033 and therefore, p < .05). The interactive effect for this group was negative (b = -0.300), which means that with the introduction of this

interaction term, the effect of SI on BI became less, i.e., people that are registered as less susceptible to social influence.

Furthermore, SAGC registration also had a significant effect on price value. The change in R^2 was 2%. This increase is statistically significant ($t = 2.115$, $p = .036$ and therefore, $p < .05$). The interactive effect for this group was positive ($b = 0.298$), which means that with the introduction of this interaction term, the effect of PV on BI became stronger (i.e., people that are registered paid more attention to price value).

5. Discussion

The moderation effects of age, gender, GIS experience, educational level and SAGC registration on the variables were tested and analysed. Results indicated that age and gender had no moderation effect on any of the variables. However, GIS experience moderated the effect of social influence and facilitating conditions on the behavioural intention to use QGIS; the educational level moderated the effect of price value; and registration with the SAGC moderated the effect of price value and social influence.

These results are consistent with a UTAUT study done by Sun (2011) about the factors that influence the diffusion of GIS in Quingdao, which also found that both age and gender had no significant effect. We anticipated that older respondents would be more reluctant to change to QGIS because age is sometimes associated with hesitance to adopt new technologies (Gallego and Bueno, 2010; Mallenius et al., 2007), but this seems not to be true for QGIS in South Africa. In contrast, Chang et al. (2019) found that older people regarded technology to make online bookings more complex, while younger users considered the usefulness of that technology. In another study, age moderated quite a few relationships related to smartphone use (Ameen and Willis, 2018). In the geospatial community of South Africa, it seems that even older GISc professionals are comfortable with using geospatial technologies. This could be due to the fact that working in the geospatial industry requires one to be technically proficient, in fact, the love of technology could be the reason for pursuing a career in geoinformatics (Coetzee and Rautenbach, 2016).

Experience moderated the effect of social influence and facilitating conditions, which is consistent with Venkatesh et al. (2003) where people with less experience were influenced more by others socially. Our results however differ from Venkatesh (2003) who found that people with less experience also paid less attention to facilitating conditions. In the case of social influence, the

effect of GIS experience was significant only for those with 5-10 years of experience, and for facilitating conditions, the effect was significant only for those with 10-15 years of experience. For those with 15-20 years of experience, the effect of both social influence and facilitating conditions was much smaller than for other age groups.

Firstly, these results show that respondents with less experience find the opinions of others more important. One would expect this, as experienced users usually develop their own opinions about a particular product. However, this could also reflect the fact that the use of a particular product is often prescribed in a work environment and users are not free to use the product of their choice. In this case, the 'important others' would be those deciding or prescribing the use of a particular product. Similarly, Morris and Venkatesh (2000) noted that as experience with a technology increases, the social influence reduces over time.

Secondly, our results show that respondents with less experience attach value to the support that is associated with a product. This is understandable, as those with less experience tend to rely more heavily on technical documentation and support services.

Our results cannot explain why the effect of social influence and facilitating conditions are significant for two particular age groups only. However, the t-values for the age groups with less than 15 years of experience are closer to each other than for the age group with more experience, supporting the notion that as one gains experience, social influence and facilitating conditions are less important when deciding to use QGIS. Future studies could focus on investigating the influence of social influence and facilitating conditions.

The educational level moderated the effect of price value on behavioural intention, i.e. respondents with a postgraduate qualification considered price value to be more important when deciding to use QGIS. Education can therefore be seen as a catalyst for understanding the value and the consequences of getting 'good value for money': a higher educational level increases 'sensitivity' to the monetary costs of GIS products. A complication is that software piracy is a problem in South Africa, as with many other countries, and this may have influenced the responses. However, this is difficult to investigate due to the sensitivity of the topic.

Registration with the SAGC moderated the effect of price value and social influence on behavioural intention to use QGIS. Since registration with the SAGC requires at least a tertiary education, it is

not surprising that it has the same effect as educational level on price value. In the South African GISc workplace setting, SAGC registration is not only a means to improve job opportunities but can also be seen as an indicator of a skill level in a socio-occupational setting. The effect of social influence suggests that registered professionals are less influenced by the perceptions of others when deciding on the use of a GIS product. This is reassuring, as professionals are expected to maintain "a high standard of professional conduct and integrity" (South Africa, 2013), i.e. one would expect their choice of a GIS product to be objective and based on facts; one would not want it to be strongly influenced by the opinions of others.

Interestingly, none of the other constructs – performance expectancy, effort expectancy, hedonic motivation and habit – were affected by any of the moderators. In other words, male or female, young or old, registered with SAGC or not and regardless of the number of years of experience or the qualification obtained, these characteristics do not matter when a GISSA member considers the performance of QGIS, the effort to use QGIS, the fun they get out of using QGIS or whether they use QGIS out of habit. Our previous paper (Henrico et al., 2021) showed that habit, followed by facilitating conditions, price value and social influence, had the greatest influence on the behavioural intention of GISSA members to use QGIS. Of these, only habit is not affected by any of the moderators in this study, that is, breaking the habit of using a particular product is a challenge regardless of age gender, experience, education level or registration status.

Educators play an important role in teaching students and prospective professionals about the pros and cons of different geospatial information products, methodologies, principles, software designs, etc., which will lead to optimal use of functionalities for solving problems in our complex world. One way to achieve this is to expose students to a range of GIS products so that they do not get into the habit of using a single product but have the opportunity to appreciate the specific value each product brings. To prepare students for the current environment of rapidly changing technologies changes and ever shorter software life cycles, they should not only be exposed to different GIS products but also to different geospatial technologies (desktop, mobile, web-based, client-server, cloud-based, etc.) and paradigms (layers, object orientation, feature-based, topology, etc). It would be useful to understand the extent to which the use of more than one product or technology has been incorporated into teaching at universities, not only in South Africa but also across the world. Similarly, it would be interesting to see if and how open-source software for geospatial has been incorporated into university curricula. Research by others suggests that the uptake is slow. Mitasova et al. (2012) reported that incorporation of open source geospatial

software into education remained a challenge. Ciolli et al. (2017) refer to the benefits of having a wide variety of FOSS4G software available for teaching, but lament that even with an open approach to licensing, the management of educational materials can still be difficult. A study about the perceptions of geography students in Romania found that the students' main reason for rejecting open source GIS tools was their fear of not being able to cope with proprietary software if they only used open source – an 'unjustified' concern, since even proprietary software differs from one another (Osaci-Costache et al. (2017).

6. Conclusions

In this study, we tested the effect of different variables on the behavioural intention of geospatial practitioners in South Africa to use QGIS. We determined whether the relationship between behavioural intention and a second variable (such as habit or facilitating conditions) is moderated by a third variable (e.g., age, gender or GIS experience). We found that GIS experience, educational level and registration with the SAGC affect some of the hypothesized relationships, while age and gender did not have any significant effect.

As one gains experience, social influence and facilitating conditions are less important when deciding to use QGIS. A postgraduate education and professional registration increase appreciation for getting value for money, which may reflect that these people are involved in purchasing decisions, and registered professionals are not significantly influenced by the perceptions of others when deciding to use QGIS. Finally, habit is not influenced by any of the moderators, suggesting that breaking the habit of using a particular product is a challenge regardless of age, gender, experience, education level or registration status.

The results of this study further contribute to understanding why South African professionals adopt FOSSGIS products, such as QGIS. The results explain which user characteristics influence behavioural intention to use a specific GIS product. This study could be repeated after a period has lapsed and people in South Africa have grown more accustomed to using QGIS. Such a study could also investigate differences between the private and public sectors, and between communities, such as statistics, planning and environmental science. A similar study in other countries or communities would reveal differences and similarities in the factors that affect the use and acceptance of a particular GIS product, FOSSGIS, or any other geospatial information technology. However, the more specialized the product, the smaller the user pool, which may weaken the significance of the results. Our results are not only useful for understanding QGIS acceptance, but they also provide

insight into the South African market of professional GIS users and are therefore useful for developers of any GIS product, whether desktop or cloud-based, open source or not. The results can also guide change management when switching from one GIS product to another, or as will increasingly be the case in future, from desktop products to cloud-based environments.

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