Assessing GIS education and GIS workforce in Saudi Arabia

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Abstract

Purpose – The geographic information systems (GIS) sector is witnessing significant growth in recent times at the global level and in the Kingdom of Saudi Arabia at the same pace. In this research, the authors aim to measure the GIS market employability in the Kingdom of Saudi Arabia, the required skills of those seeking GIS employees, existing knowledge and abilities of graduates of relevant academic programs and gaps, if any, between the graduates and the labor market requirements in terms of GIS. Research on GIS education and GIS employability from an information system perspective is scarce; thus, this study is needed.

Design/methodology/approach – In this study, a questionnaire was distributed manually and electronically to a specific group of GIS students, teachers and employees. The questionnaire was prepared in Arabic and English language. It was distributed manually to the attendees of the 12th GIS Symposium, organized by Imam Abdulrahman Bin Faisal University at Dammam city, Saudi Arabia in April of 2018. The event is a yearly one that gathers local GIS community and outside speakers and guests. An electronic version of the questionnaire was also available and distributed via personal contacts. Responses were received until the end of 2019.

Findings – The results of 107 respondents indicates good GIS foundation (for example in topology, geospatial data processing and cartography); however, programming and business skills (namely cost benefit analysis, organizational perspective and business understanding) are lacking from Saudi GIS graduates. About 67% of respondents acknowledge directly that it is difficult to find locally qualified GIS graduates. Moreover, 55% of respondents classify GIS job candidates as underqualified. This research identifies under qualification in business competencies and computer programming skills for GIS students and workers in Saudi Arabia. This research did not find a statistically significant different response between GIS teachers and GIS employees/employers; however, students' response was significantly different from these two groups.

Originality/value – Research on GIS education and GIS employability from an Information System perspective is scarce; thus, this study is needed. Moreover, research about this topic in Saudi Arabia and the Arabian Gulf is almost nonexistent.

Keywords GIS, Workforce, Education, Saudi Arabia, Empirical study

Paper type Research paper

1. Introduction

Saudi Arabia is enduring a huge digital transformation both in the public and the private sector. Thus, geographic information systems (GIS)-related applications are expected to thrive subsequently. There are many uses of GIS starting from land and town planning, statistics, environmental monitoring and studying the weather, geography and water, the analysis of diseases and epidemics and how they spread down to the contribution of GIS in the decision-making process.

There is substantial literature about GIS employment in USA (Solem, Kollasch, & Lee, 2013), United Kingdom (UK) (Seremet, 2013), Turkey (Şeremet and Chalkley, 2016),

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New Zealand (Róiste, 2014) and South Africa (Du Plessis, 2015). However, similar studies do not exist for Saudi Arabia.

In Saudi Arabia, much of the published studies are about GIS applications in Hajj (Koshak, 2006), water and flooding (Saud, 2010), healthcare (Murad, 2004), traffic (Aljoufie, Zuidgeest, Brussel, & VanMaarseveen, 2013), oil and gas (Mahmoud, Ahmed, Krinis, & Al-Marri, 2005). The other side of GIS studies in Saudi Arabia have focused on GIS adoption and uses Alsultana & Rahmanb, 2015; Alzighaibi, Mohammadian, & Talukder, 2016; Kubbara & Maniruzzaman, 2013). The most relevant research found was that of Aina (2009) and Aina, Aleem, Hasan, AlGhamdi, and Mohamed (2014), which have focused more on the field of geomatics in the case of Yanbu Industrial College. This research is more concerned with GIS technology across all Saudi universities and colleges.

More recent GIS research in Saudi Arabia has focused on the practical side of applying GIS to studying the implications of deploying hydrogen in off-grid electric vehicle charging stations (Elshurafa, Muhsen, & Felder, 2022), disease mapping such as COVID-19 (Murad and Khashoggi, 2020), traffic collision analysis in Dammam city (Rahman, Jamal, & Al-Ahmadi, 2020), earthquake hazard assessment in Jizan city (Abdelrahman *et al.*, 2021) and flash flood risk at NEOM mega city (Abdulalim and El Damaty, 2022). However, recent work about GIS education/employability in Saudi Arabia could not be located.

Aina (2009) in his study, examined the field of geomatics (the engineering terminology for spatial systems) in Saudi Arabia and found diversity in teaching this subject (some offer a full degree in it while other universities only provide it as selective courses along another degree) and exclusively for male sections. Aina (2009) also noted low enrollment numbers of students in these programs/courses as the subject is still new to them, and employment opportunities are not as wide as other established engineering disciplines. Al-Garni (2010) from the College of Engineering at King Saud University Department of Civil Engineering talked about GIS in the surveying program and stated that there is a need for more GIS experts in the field; at the same time, there seems to be low awareness about the potential employment in GIS among junior students in the engineering school who are yet to pick a field to major in. Kubbara and Maniruzzaman (2013) examined the possibility of teaching GIS online in Saudi Arabia and outlined some criteria and resources. Alsultana and Abdul Rahman (2015) analyzed the context of GIS from a state perspective and suggested establishing a national geospatial center to coordinate the sharing of GIS data, enforcing standards and building the required infrastructure.

The aforementioned literature although relevant does not satisfy the needs of this study. First these studies are dated, and a current study is needed to take into consideration the change in the environment (economy of Saudi Arabia, changes in the GIS technology and regulations) and the change in academia (accreditations, new universities and colleges). Second these studies are not comprehensive (did not cover all Saudi universities or a statistically representative sample of the GIS job sector). Third, no strong link has been constructed to align GIS education with employment in GIS jobs. Lastly, these studies have originated from engineering schools and the perspective of the computing schools has yet to be considered.

In this research, we aim to assess GIS workforce in the Kingdom of Saudi Arabia, the required skills of those seeking GIS employees, existing knowledge and abilities of graduates of relevant academic programs and gaps, if any, between the graduates and the labor market requirements in terms of GIS. This research will be guided by the following questions: what is the current state of GIS education in the colleges and universities of Saudi Arabia? What is the current employability of GIS graduates in Saudi Arabia? Is there a gap between GIS education and the actual GIS market needs in Saudi Arabia?

To the best of our knowledge, this is the first study in Saudi Arabia that performed a comprehensive assessment of GIS education and workforce assessment using the geospatial technology competency model (Gaudet, Annulis, & Carr, 2003).

2. GIS body of knowledge

Du Plessis (2015) in his PhD thesis assessed the skills and competencies of GIS professionals and GIS programs in South Africa. The end result of his work was a web-based self-assessment tool of GIS skills. To accomplish that goal, he used a combination of qualitative and quantitative procedures. Also Seremet (2013) in his PhD thesis studied GIS education in the UK and Turkey through mainly 10 case studies of Geography department in both countries and utilized both quantitative and qualitative methods that included questionnaires, interviews, observations and reading course contents. In the *Journal of Geography in Higher Education*, Solem *et al.* (2013) studied the motivation of geography graduates in the USA through two surveys (students and faculty) and used appropriate statistical methods for analysis (*t*-tests, ANNOVA exploratory factor analysis and logistic regression). Moreover, Bowlick, Goldberg, and Sarah Witham Bednarz (2017) in the *Journal of the Professional Geographer* reviewed the websites of geography departments in the USA to explore the extent of teaching programming and computer science courses in their programs and mainly used content analysis methods. Hennemann and Liefner (2010) also in the *Journal of Geography in Higher Education* analyzed the employability of German geography graduates through student survey. In the Journal of Transactions in GIS, Wikle and Fagin (2015) explore the hard and soft skills of GIS professional by a survey conducted on GIS educators and GIS employers. To the point, Róiste (2014) in the Journal of New Zealand Geographer, surveyed 157 organizations in New Zealand to determine whether there is a shortage of geospatial skills in New Zealand.

To build these surveys, previous research has relied on established frameworks and models of GIS competency, specifically

(1) The UC GIS/GIS&T Body of Knowledge (DiBiase *et al.*, 2007),

(2) Doleta geospatial technology competency model (Babinski, 2012) and

(3) GIS core curriculum by NCGIA (Kemp, 1997).

This research followed the same line of thinking and used similar research methodologies as they have been applied to the same problem in other countries. A questionnaire was developed for students, faculty and employers to assess current GIS education (knowledge, skills and competency) and GIS employability. Although many and more recent GIS competency models exists (such as DiBiase *et al.*, 2010), in this research, Gaudet *et al.'s* (2003) geospatial technology competency model was used.

The geospatial technology competency model was developed by the Geospatial Workforce Development Center at the University of Southern Mississippi, USA under a The National Aeronautics and Space Agency (NASA) contract around 2003. The purpose of the model was to assess the competency of workers in the geospatial industry. The model suggested 12 work roles (application development, data acquisition, coordination, data analysis, data management, management, marketing, project management, system analysis, system management, training and visualization) geospatial practitioners could play/serve. More importantly, 39 competencies (skills and knowledge necessary to accomplish a task or perform a role) geospatial practitioners should poses were identified. These 39 competencies (topology, cartography geospatial data processing tools, geospatial technologies, communication, conflict management, self-management, relationship building, GIS theory, spatial information processing, creative thinking, photogrammetry, feedback skills, systems thinking, problem solving, leadership, questioning, knowledge management, group process understanding, ability to see the “Big Picture”, coaching, technical writing, model building, research, technological literacy, remote sensing, change management, environmental applications, visioning, geology applications, performance evaluation, industry understanding, legal understanding, business understanding, advocacy, ethics modeling, computer programming, organization understanding and cost benefit analysis) were grouped into four areas, namely technical, business, analytic and interpersonal. Then a matrix was presented to specify the competencies needed to satisfy each role. It can be seen by examining recent citations of this model (2021 and 2022) that it is still used to assess GIS education and workforce and thus justifies its use.

The reason is the simplicity of the model through dividing the competencies over four categories (technical, business, analytical and interpersonal skills) yielding a total of 39 competencies, which could be assessed directly through a single item. Using a more sophisticated GIS competency model with additional competencies would require more questions and deem the questionnaire unanswerable due to the length and lack of motivation for filling.

3. Reaserch design

The first part of the questionnaire was about demographic information of the participant. The second part was intended for students only to ask them about their GIS education. The third part was for GIS teachers to inquire about their GIS teaching. The fourth part was for GIS employees (or employers) to ask about the organization they currently work on or manage. The fifth part was the main section of the questionnaire. The competency part (skills) of the questionnaire was based entirely on Gaudet *et al.* (2003) model as previously explained. The student was expected to answer based on the degree he/she thinks his/her GIS education helped in enriching each skill. Teachers were expected to answer based on the extent their GIS courses helped in developing each skill set. Employees or employers were expected to answer based on the extent they think each skill is important for the work their GIS staff performs in the organization. The competencies were assessed using a four point skill that starts with never, rarely, sometimes and frequently. This method of frequency separation was used to discriminate clearly between missing skills (never) and highly needed or used skill (frequently). This was chosen over the strongly agree/disagree scale more applicable to opinions rather than actual practice. The last question was an open ended question that asked participants if there is anything they would like to add concerning GIS education, employment or the GIS workforce in Saudi Arabia. The questionnaire is available online at https://forms.gle/1b2UpEfcj6bMha6U6

The questionnaire was prepared in Arabic and English language. It was distributed manually to the attendees of the 12th GIS Symposium, organized by Imam Abdulrahman Bin Faisal University at Dammam city, Saudi Arabia in April of 2018. The event is a yearly one that gathers local GIS community and outside speakers and guests. An electronic version of the questionnaire was also available and distributed via personal contacts. Responses were received until the end of 2019.

In total, 110 responses were received. Three of the respondents did not fill the competency part. Of those filled (107) questionnaires, 16 participants left some of the competencies unanswered. 55 responses were collected manually via paper hand by hand after the end of the symposium. Another 55 were collected electronically via Google Forms. Only three responses were in English language while the rest was in Arabic. Of those filled questionaries, 25 categorized themselves as students, 22 were teachers and 60 were employed.

4. Data analysis

The demographic section of the questionnaire was optional, so some of the respondents did not fill it, and we report here from the filled responses. Males represented 65% of the sample. In terms of age group, 21% of the sample were between the ages of 18 and 25, 35% were between 26 and 35 and 44% were older than 36 years. With regards to GIS experience, just 13% of the sample had less than a year of experience, 35% had between 1–3 years of experience, 31% had between 4–10 years of experience and 21% had more than 11 years of experience with GIS. In terms of the highest education degree, the respondents held at the time of the questionnaire, 11 had a diploma or less, 55 had a bachelor degree and 43 had a graduate degree. When asked about the university, the respondents received their last education from or currently teach at, 18 were from King Faisal University, 11 were from Imam Abdulrahman Bin Faisal University, 8 from King Saud University, 7 from King Abdulaziz University, 2 from University of Jeddah, 3 from Qassim University, 1 from Princess Nourah Bint Abdulrahman University, 1 from Imam Mohammad Ibn Saud Islamic University and also 1 also Effat University. There was also five responses from outside Saudi Arabia from Salem State University (USA), the University of Akron (USA), one from a German university, one from Al-Hussein Bin Talal University (Jordan) and one from Redlands University (USA).

When asked about the schools students currently study at, 39 of respondents were studying at the College of Arts geography department, 6 in the College of Architecture & Planning, 2 from the Engineering School and 2 in the Geomatics department. About 51% of the student sample studied in programs that offered more than five courses in GIS, which represents a satisfying number at least from a quantity perspective.

The teachers' samples are consistent with the students in terms of college (74% teach in the arts college, geography department) and also the number of different GIS courses offered (46% offer more than 5 courses of GIS). When asked about the QIS software used in these courses (the respondents were given the option to choose more than one vedor), 67% use ESRI products, 23% use QGIS (free open source GIS software), 23% use Google products, 7% use Bentley software and also another 7% still use Autodesk, 9% use Intergraph/Hexagon software and one respondent uses the Grid Analysis and Display System (GrADS). More to the point, when asked directly if open source GIS is used, 63% reported the use of open source GIS. 87% have a lab or tutorial component in their GIS courses and 80% report the presence of a project in the grade distribution. Further investigation reveals that 68% of the sample face difficulty in obtaining GIS data for these projects from local public or private sector.

Public organizations where respondents work represented 61%, private organization accounted for 35% and 4% for non-for-profit organizations. Big organizations where more than 101 employees work accounted for 69% of the sample. When employee/employers were asked directly if they perceived difficulty obtaining qualified GIS graduate of a Saudi university/college, 68% acknowledged the scarcity of suitable candidates. To further classify GIS job candidates based on the respondents' experience of the hiring process, 55% believe candidates are under qualified, 5% state that they are over qualified and 40% think they are correctly qualified.

The main part of the questionnaire was an assessment of current GIS competencies in Saudi Arabia and table one summarizes the results of all respondents.

It can be seen from Table 1 which is ordered by the sum column that the top three competencies found (in education) or needed in the job market are topology (editing and correcting spatial data), cartography (map drawing and design) and geospatial data processing. Looking at the bottom of Table 1, it is clear that cost benefit analysis (ROI), organization understanding and computer programming are not covered enough in GIS education or practiced. When the never column is examined (the competency is not used), it can be seen that ethics modeling, advocacy, legal understanding, business understanding,

Competency	Never	Rarely	Sometimes	Frequently	Mean	Standard deviation	Sample variance	Sum
Topology	4	2	23	78	3.64	0.71	0.5	389
Cartography	3	8	20	76	3.58	0.75	0.57	383
Geospatial Data Processing Tools	3	6	22	75	3.59	0.73	0.53	381
Geospatial Technologies	3	5	31	68	3.53	0.72	0.52	378
Communication	3	5	29	69	3.55	0.72	0.52	376
Conflict Management	4	7	26	69	3.51	0.78	0.61	372
Self-Knowledge/ Self-Management	3	6	32	65	3.5	0.73	0.54	371
Relationship Building Skills	6	6	28	66	3.45	0.84	0.71	366
GIS Theory and Applications	4	10	28	64	3.43	0.82	0.67	364
Spatial Information Processing	6	9	28	64	3.4	0.87	0.75	364
Creative Thinking	5	6	30	64	3.46	0.81	0.65	363
Photogrammetry	7	8	29	63	3.38	0.89	0.79	362
Feedback Skills	6	6	32	62	3.42	0.84	0.7	362
Systems Thinking	5	9	27	64	3.43	0.84	0.71	360
Problem Solving Skills	6	7	30	62	3.41	0.85	0.72	358
Leadership Skills	6	9	27	63	3.4	0.87	0.76	357
Questioning	6	8	29	62	3.4	0.86	0.74	357
Knowledge Management	5	6	27	64	3.47	0.82	0.67	354
Group Process Understanding	8	6	26	64	3.4	0.91	0.83	354
Ability to see the “Big Picture”	7	9	32	58	3.33	0.89	0.79	353
Coaching	8	6	31	60	3.36	0.9	0.81	353
Technical Writing	5	11	39	52	3.29	0.84	0.7	352
Model Building Skills	6	7	33	58	3.38	0.85	0.72	351
Research Skills	5	10	34	56	3.34	0.84	0.71	351
Technological Literacy	4	16	35	52	3.26	0.85	0.72	349
Remote Sensing	6	19	32	50	3.18	0.92	0.85	340
Change Management	13	9	31	53	3.17	1.03	1.06	336
Environmental Applications	7	17	41	41	3.09	0.9	0.81	328
Visioning	13	10	35	47	3.1	1.02	1.04	326
Geology Applications	13	17	35	41	2.98	1.02	1.05	316
Performance Evaluation	14	16	33	42	2.98	1.05	1.1	313
Industry Understanding	12	17	37	38	2.97	1	1	309
Legal Understanding	15	16	35	39	2.93	1.05	1.1	308

(*continued*)

Table 1.
GIS competencies (values from column never to frequently represent frequency count while the rest represents quantification of categories never = 1, rarely = 2, sometimes = 3 and frequently = 4)

Competency	Never	Rarely	Sometimes	Frequently	Mean	Standard deviation	Sample variance	Sum
Business Understanding	12	19	39	35	2.92	0.99	0.97	307
Buy-in/Advocacy	14	17	33	40	2.95	1.05	1.09	307
Ethics Modeling	15	14	36	38	2.94	1.05	1.09	303
Computer Programming	15	22	33	36	2.85	1.05	1.1	302
Organization Understanding	13	21	41	30	2.84	0.98	0.96	298
Cost Benefit Analysis/ROI	17	20	36	33	2.8	1.05	1.11	297

Table 1.

Technical	Business	Analytical	Interpersonal
3.32	2.99	3.42	3.44

Table 2.
Core GIS competencies

performance evaluation, industry understanding, geology applications, visioning and change management are quit high compared to the rest of the table. Table 2 shows the results of Table 1 grouped by their category.

Table 2 represents all responses coded from 1 = never to 4 = frequently. It can be seen that the highest competencies found are interpersonal (communication, leadership [. . .]) and analytical (problem-solving, system thinking [. . .]). Also technical competencies (topology, cartography and geospatial data processing) are fairly supported (global average is 3.27). There exists a clear problem in business competencies. It seems that GIS education and job environments do not support and enrich business skills of GIS graduates adequately.

If frequently, sometimes and rarely are collapsed into agree/use and never with missing values is treated as do notagree we get Table 3.

Table 3 is ordered by the last column. It can be seen again that business and programming skills are lacking. Also basic GIS and geography fundamentals are almost completely covered/used by education/workforce. When Pearson correlation is ran among competencies, the results are too large to fit paper format. But the average correlation is positive 0.49, and the item of the competency categories (technical, business, analytical and interpersonal) correlate among each other above this average especially business, analytical and interpersonal items. Computer programming skills correlated the least (average of 0.32) with all other items. Problem-solving and model building skills were the highest (0.89) correlated with each other. Least correlated items (0.06) were group process skills with cartography.

To investigate the results more deeply, responses were separated into students, teachers and employees. The detailed tables for each group will be too long for this paper, but the main results will be reported. For GIS teachers, computer programming are least gained, while cartography, topology, data processing and system thinking are highly emphasized in GIS teaching according to the sample. For GIS students, business and organization understanding and cost benefits analysis are least gained by their education. Cartography and data processing are reported as highly supported by the student's education in the sample. For GIS employees, geology applications, computer programming, ethics modeling and legal understanding are less important in their current work. Topology and cartography are reported as the most frequent in daily GIS work. To investigate if the differences between groups are statistically significant, a set of t tests are performed and Table 4 shows the results.

Competency	Agree	Don't agree
Ethics Modeling	88	19
Cost Benefit Analysis/ROI	89	18
Buy-in/Advocacy	90	17
Legal Understanding	90	17
Computer Programming Skills	91	16
Performance Analysis and Evaluation	91	16
Industry Understanding	92	15
Organization Understanding	92	15
Visioning	92	15
Geology Applications	93	14
Business Understanding	93	14
Change Management	93	14
Group Process Understanding	96	11
Knowledge Management	97	10
Coaching	97	10
Model Building Skills	98	9
Environmental Applications	99	8
Ability to see the "Big Picture"	99	8
Problem Solving Skills	99	8
Leadership Skills	99	8
Questioning	99	8
Photogrammetry	100	7
Creative Thinking	100	7
Research Skills	100	7
Systems Thinking	100	7
Feedback Skills	100	7
Relationship Building Skills	100	7
Remote Sensing Theory and Applications	101	6
Spatial Information Processing	101	6
GIS Theory and Applications	102	5
Technical Writing	102	5
Conflict Management	102	5
Geospatial Data Processing Tools	103	4
Technological Literacy	103	4
Topology	103	4
Communication	103	4
Self-Knowledge/Self-Management	103	4
Awareness of Geospatial Technologies	104	3
Cartography	104	3

Table 3.
GIS competencies collapsed into two categories

	Teacher and students	Teachers and employees	Students and employees
P value	8.42369E-16	0.1585574	1.8896E-27

Table 4.
T tests between groups

It is apparent that there is no statistically significant difference between the responses of the teachers and employees. However, student responses vary significantly (<0.005), meaning that what students actually perceive from their GIS education is different from what their teachers are giving them or what is actually needed in today's working environment.

5. Discussion and conclusion

Based on this research, it seems that GIS foundations are fairly covered by current GIS education. However, respondents have indicated deficiency in remote sensing skills. It was surprising to see that the sum of photogrammetry skills (362) was higher than remote sensing (340). It could be argued that respondents were not able to distinguish between the two and remote sensing sounded more complex. There is an apparent result out of this research to integrate more computer related courses and knowledge (programming and emerging technologies) to the curriculum of GIS. Business related competences (change management, visioning, performance evaluation, industry understanding, legal understanding, business understanding, buy-in/advocacy, ethics modeling, organization understanding and cost benefit analysis/ROI) scored low in this research and again warrants the need to increase these type of courses in GIS education. Interpersonal and analytical competencies scored the highest, and it seems that GIS graduates in Saudi Arabia exhibit excellency in them. Student comments from the open-ended question, stressed the need to increase GIS training and especially Saudi female training needs and practical experience through internships which lead to direct employment. Computer programming scored the lowest among competencies for teachers and employees; however, for students, the lowest was cost benefit analysis and organization understanding. It is apparent from this research that one important step to improve GIS education in Saudi Arabia is to expand business related courses.

When analyzing the open-ended questions for the employees segment, it can be reported that they perceive the following gaps in Saudi GIS graduates as it relates to their current work:

(1) English language proficiency,

(2) Practical training and experience with advanced GIS features,

(3) Web programming,

(4) Self-learning and exposure to new technologies and

(5) Data preprocessing and data quality assurance.

One respondent has indicated that in order to fix these gaps, GIS should be pulled out of the geography umbrella and be regarded much like mathematics, where each school takes what it needs out of it.

Exactly 68% of respondents to this research acknowledged the difficulty of obtaining local GIS data (locations of car accidents, burglaries, fire incidents or traffic congestion) to be used in course projects, research or even government/private work initiatives. If such data are more easily available, it is to be expected that more advanced local GIS projects can be implemented, which would also help grow the local GIS industry and workforce.

It should be taken into consideration that the majority of responses came from universities in the eastern part of Saudi Arabia. Also most responses came from arts, engineering, planning and architecture schools. Thus, the result of this research applies to them more than others. Also there was a gap between the time the data were collected and the writing of this paper. The GIS competency model used is in English language, and the researcher did his best to translate it into Arabic. These limitations should be noted. For future work, the results should be compared with an in-depth analysis of course syllabus of GIS courses or programs in Saudi Arabia along with content analysis of GIS career job description in Saudi Arabia.

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Further reading

فوزي سعيد كباره (٢٠٠٢) تقييم استخدام نظم المعلومات الجغرافية في المملكة العربية السعودية.

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