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Architectural Software Preferences in Correlation to Architectural Skills

Adham M. Mohammed
Department of Architectural Eng., Faculty of Eng., Assuit University, Assuit, Egypt.
(Corresponding Author: Adham@aun.edu.eg)

Abstract
The present study explores the correlation between architectural skills and software user preferences, thereby offering insights for software developers to tailor their products effectively according to users' varying skill levels. Accordingly, a questionnaire was employed to delve into the perspectives of three distinct user groups, each possessing different levels of architectural skills. The primary aim of this inquiry was to pinpoint the key characteristics that hold significance for users within each skill level. Analysis of the responses revealed significant correlations between architectural skill and software preferences, highlighting variations in preferences based on skill levels. Key factors such as ease of use, customization, and compatibility with other tools emerged as particularly influential among users. The findings provide valuable assistance for developers in terms of designing software that is user-friendly and highly effective. Additionally, these findings can be utilized to evaluate the suitability of software, ultimately enhancing the process of software evaluation.

Keywords: *Architectural software; Architectural skills; Software users; Software development; Preference.*

1. Introduction

Architectural computer software is integral in the field of architectural for its effectiveness, accuracy, and time-saving benefits [1, 2]. This is true for both architectural learning and commercial architectural practice [1, 3, 4]. Architectural software can be used in miscellaneous contexts, such as precise drafting or contributing to the design process. Other non-architectural software can also be used to aid architectural design such as rendering and presentation software. Examples of commonly used software in the architectural context are Autodesk® AutoCAD, 3DStudioMAX, Revit, Lumion®, Google SketchUp, and Adobe® Photoshop® [1, 2]. As such, the dependency on software is growing [1, 3], motivating developers to optimize their products.

1.1. Architectural education

Literature emphasizes the influence of software on architectural study; Soliman et al., 2019 [1] confirm that software study can be optimally included within different phases of architectural study. Also, a similar study [9] mentions that educators' and students' prefer computer-aided design (CAD) due to accuracy, pen assignments, presentation, ease of modification, and overall quality. This is also true for BIM software [10, 11]. Likewise, a related investigation confirms that the use of software is important, especially in terms of visualization [12]. Another study states that industry requirements resulted in the architectural engineering disciplines effectively integrating CAD learning into their curricula [4]. Similar remarks are found in the work of related studies [13–15]. Also, The use of augmented reality software in architectural learning is equally important, as it increases spatial abilities and aids cognitive processes [16–19]. Therefore, studies forecast that software will result in significant changes to the architectural process, specifically the way in which students envision architecture, which requires reconsideration on student utilization methods of software [20].

1.2. Architectural design and construction

The importance of architectural software extends to the architectural commercial practice. Acheng et al., 2022 [21] analyzed the condition of BIM in Uganda's and shown that BIM increased productivity and enhanced design quality, confirmed by comparable findings [10]. Another study specifies that computer software can aid the design process despite resulting in some deficiencies [7]. Similarly, a study indicates that CAD allows for higher productivity and better quality in architectural offices [22]. Likewise, a study utilizing an AR process to facilitate access to design information, and demonstrate that AR workflow potentially saves time and eliminates mistakes [23]. Similar work further confirms this [24–27]. A study on the influence of CAD on design and creativity, lead to useful advice for architectural designers and ways to enhance computer systems[28]. Other studies have confirmed the advantageous gains that are to be expected from architectural software [29].

1.3. Role of software users

Literature affirms that computer software, in general, must be designed with the user experience and requirements in mind to optimize software interactivity [30–32], in addition to being visually appealing and comprehensive of technical guidance [33, 34]. Accordingly, software designed based on human-computer interactions are more successful [31, 35], whereas, failing to involve users' feedback can hinder the users' ability to associate the appropriate software tools with required tasks [36, 37]. Hence, users and developers are seen as a unified community [38]. Collaboration between them can help and address issues, analyze contexts, and identify user patterns [32, 39, 40]. However, it is reported that development efforts can focus on fixing malfunctions with little regard to user needs [30], resulting in possible analytical deficiencies [41]. In fact, developers sometimes are unaware of the existence of human-computer interaction approaches for software design [42]. Therefore, it is crucial to shift attention to educating developers on users' role as integral stakeholders of software designs [43].

2. Research problem

It is clear that different software users have varying needs based on their skill levels; for example, novice students may need simplified features compared to experienced architects. While literature suggests that successful software must be based on the requirements and feedback of users, much architectural software is generically designed with little regard for users' requirements. This can result in user dissatisfaction. Hence, software development should prioritize individual user feedback based on skill, rather than relying on collective feedback.

3. Gap and novelty

Despite the apparent correlation between users' skills and software preferences there is a lack of research on this relationship, creating a knowledge gap. A robust understanding of the effect of user status on software preferences allows for novel information that aids developers in tackling factors that affect the commercial success of architectural software, which can lead to increasing software proficiency, productivity, and profitability.

4. Aim and scope

This study aims to explore how the experience, education, and professional role of architectural software users, relate to their perceptions, cognition, and requirements of the software; the goal is to understand the perspectives of users with varying levels of architectural skill. The study's outcome is intended to: a) discern the characteristics of differently skilled groups of architectural users; b) guide the development and customization processes of architectural software; c) act as a scale for measuring architectural software suitability. It is worth noting that the study focuses on the outlining characteristics of software (such as practicality and cost), not their detailed functions (such as 2D drafting, 3D simulation, etc.). The study's outcomes are directed to benefit developers in further optimizing their software, in addition to aiding architectural professionals and students in selecting software appropriate for their tasks.

5. Assessment Factors

Information obtained from official websites, discussions with experts and students, and relevant literature was utilized to outline many factors that influence users' satisfaction. Table 1 shows the mentioned factors and software examples (presented in "*Available in Software*"). Initially, twenty-four factors were determined and categorized into four distinct groups based on similarity or scope. For example, (ease of learning) and (ease of installation) both relate to the easiness of use, hence belong to the same Facility category. Also, similar factors were merged to simplify the questionnaire and analysis process. Factors pertaining to "function" were omitted from this list and investigated separately as they are subjective and out of the study's scope as mentioned in section 4. Furthermore, the investigated factors apply to all software regardless of their function. Ultimately, nine main factors are identified, grouped into three categories: Facility (software usability and comprehensibility), Device requirements (devices' properties), and Licensing (cost of legal acquirement). While some software have dedicated tools for certain functions, others only have limited complimentary features. In the latter case, the software is considered to not support that particular function.

6. Questionnaire & Results

A questionnaire is carried out involving local architectural students and architects of different architectural skills, which were accordingly categorized, as shown in Table 2. Naturally, it was crucial that the participants are of varying skills to accurately reflect its influence on software preferences. For the purposes of the study, the term "architectural skills" of the users is used to describe characteristics such as:

- Architectural design experience.
- Architectural Competence.
- Software experience.
- Architectural education.
- Professional position and experience.

Table 1: Influencing factors & software examples.

Factor		Description	Quantifiable	Perceptual	Available in Software: Autodesk® AutoCAD	Autodesk® 3DSMAX	Autodesk® Revit	Autodesk® Maya	Lumion®	Rhinoceros®	Google SketchUp	Blender 3D™	Oracle® Primavera	Coral Draw®	Adobe® InDesign®	Adobe® Photoshop®	Proposed by experts	proposed by author
Function	2D drafting	Allows for high accuracy 2D drawings	●		●		●							●			●	●
	3D modeling	Specializes in 3D Modeling (excluding rendering capabilities)	●		●	●	●	●		●	●	●					●	●
	BIM	Entails of complete BIM capabilities	●				●		●									●
	GIS	includes location-based tools	●		●	●			●		●							●
	Annotation	Contains 2D annotation tools	●		●		●							●				●
	Animation^	Allows for 3D building animations	●		●	●	●	●	●	●	●							●
	visualization^	Allows realistic renders of 3D models	●			●	●	●	●	●	●	●						●
	Image editing	Image post-production management	●											●	●	●		●
	Site management	Organization of site operations	●										●					●
Facility	Ease of learning	Does not require extensive training		●													●	●
	Online support *	Official support/material offered	●		●	●	●	●		●	●	●		●	●	●	●	
	Informal learning *	Unofficial learning material available	●		●	●	●	●	●	●	●	●	●	●	●	●		●
	Installation **	Easily/quickly installed, no help required		●														●
	Simplicity **	Contains an easily readable interface		●													●	●
	Recurring upgrade & AI assistance **	Frequently upgraded by developers, entails smart AI tools or smart assistants	●		●				●								●	●
	UI customization **	Allows significant interface customization	●		●	●	●	●	●	●		●		●			●	●
	Compatibility **	Compatible with files from other software	●		●	●	●	●	●	●	●	●		●	●	●		●
	Collaboration **	Allows simultaneous participation of multiple users on a single file	●		●	●	●							●			●	●
System requirements	Hardware requirements	Does not require high processing speeds or computational power to operate		●														●
	Operating system	Does not require latest OS to operate	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Stability	Minimal tendency to crash or malfunction	●															●
License and cost	Cost	Free license or of relative low cost	●								●	●						●
	Free trial	Includes a period of free-trial	●		●	●	●	●	●	●				●	●	●	●	●
	Payment plan	One-time payment or recurring subscription/charge		●													●	●

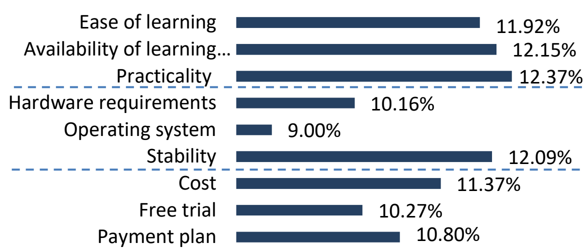
Notes: - Quantifiable: denotes a measurable factor.
- Perceptual: denotes a factor associated with individual perception or circumstances (grey).
- Annotation is merged under "2D drafting".
- ^ Factors were merged with "3D modeling".
- ***** Factors merged and named "Availability of learning materials".
- ****** Factors merged named "Practicality".

It is difficult to accurately determine the participants' status in terms of the mentioned characteristics; for instance, it is hard to quantify architectural competence. To compensate, the study relied on approximately measuring skills based on the participants' study level for the lower levels (*L1* and *L2*). The (*L3)* participants consisted only of architects with an academic and field experience of no less than three years. For further accuracy, the number of participants for *L1* and *L2* was intentionally greater than for *L3*, as they were composed of students with varying proficiencies; hence, this was important to ensure that the survey's outcome is inclusive.

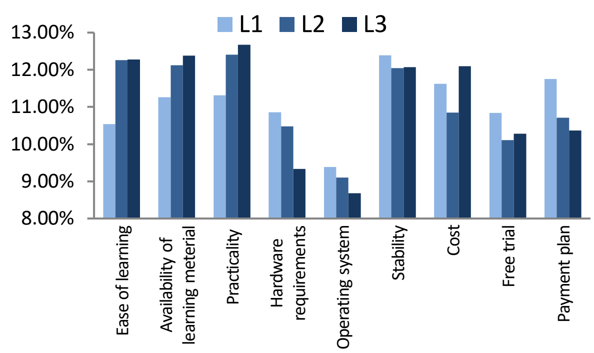
Table 2: Participants' categories

Level	Competence	Study Year	Software Experience	Design Experience	Commercial Experience	Number of Participants
L1	Novice	1st & 2nd	Low-Mod.	Low	No	25
L2	Skilled	3rd & 4th	High	Mod.	Low	31
L3	Expert	Grad.	High	High	3 – 25 y	13

-"Mod." Denotes Moderate



(A)



(B)

Figure 1: (A) Average responses for each factor. (B) Average responses for each level.

The respondents were required to express their views on the significance of the factors, including a score for each group of factors. A Likert scale was adopted on a scale from 1 to 10 (with 1 being the least significant and 10 the most). The scores obtained from the questionnaire (Appendix A) allow for calculating the significance of each factor, from the users' perspectives. **Error! Reference source not found.** (A) shows the significance of factors based on the average responses from all three groups of respondents. **Error! Reference source not found.** (B) shows the significance of factors based on the separate responses of each level, taking into account the factor group's significance.

7. Discussion

On average, factors that relate to "*Facility*" seem to be of slightly higher significance, followed by "*Device requirements*" then "*Licensing*". This outcome is reasonable as learning and operating a piece of software influences workflow and productivity. Conversely, many academic institutes provide free software, in addition to software developers offering relaxed payment plans; this explains the relatively lower significance of "*Licensing*". Issues relating to "*Device requirements*" do not pose a significant obstacle to students or professionals, as devices are becoming affordable with increasing technology. It is important to point out that considering a factor of low significance does not particularly imply that it is trivial, rather an easily controlled issue. Lastly, a strong correlation can be seen between the responses of each level, further confirming the responses' validity. 2 illustrates examples of the changes that occur in preferred software aspects in accordance to architectural skill, as explained in detail in the upcoming section. The responses allow for further insights as follows:

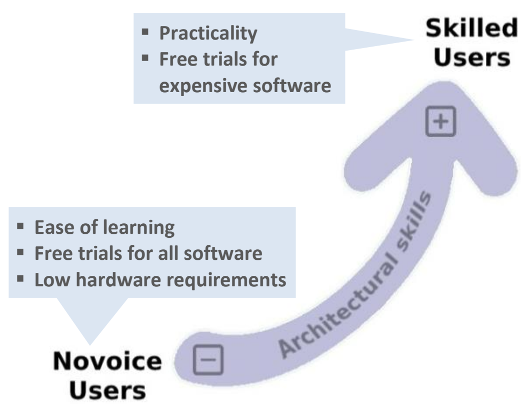


Figure 2: Examples of preferred characteristics according to architectural skill.

7.1. Software Facility

Although the simplicity of learning a piece of software is essential, it is transitory; Users only go through learning once, whereas the software's practicality permanently affects productivity; this justifies the higher significance of "Practicality" compared to the other two factors in the group, as **Error! Reference source not found.**(A) shows. Hence, "Practicality" holds a higher significance due to the lasting impact on productivity, unlike the transitory nature of learning ease. Also, the separate opinions of respondents' levels show that, for each factor, there is a consistent correlation; Opinions of *L3* and *L2* are fairly similar, with *L3* slightly higher, followed by *L1*, as seen in **Error! Reference source not found.**(B). This implies that skilled users better appreciate practicality. Hence, *L1* are constantly showing a much lower score of factor-significance, as they lack this experience. Accordingly, it is correct to assume that software development should prioritize that enhance long-term productivity.

7.2. Device requirements

Stability is most significant within this group, as **Error! Reference source not found.**(A) shows. Naturally, software's tendency to crash or malfunction hinders productivity. *L2* and *L3* share a comparable opinion on this matter. The lack of stability can be particularly frustrating for unconfident novice students, which explains L1's high score for stability. A pattern is also seen for "Hardware requirements" and "Operating systems". L3 views these factors as unimportant, likely as they have the financial means to upgrade their hardware and software. "Operating systems" are regarded as of low significance, possibly due to the availability of free or low-cost student versions. Also, software development has seemingly evolved to be cross-platform, allowing applications to run on multiple operating systems without significant modification. This reduces reliance on specific operating systems. Open-source operating systems have also influenced this by enabling users to overcome proprietary limitations.

7.3. Software Licensing

The fiscal aspect is inherently important in real-life projects; **Error! Reference source not found.**(A) demonstrates this as the cost of obtaining a license for a piece of software is most important within this group. It is important to note that there are many factors that contribute to pricing, however, these are out of the study's scope as it focuses on the effect of cost rather that its determinants. **Error! Reference source not found.**(B) points out that *L3*'s experienced members perceive the financial aspects, "*Cost*", to be of more importance, which can be a result of real-life experience. *L1* follows *L3*, which may be explained as novice students usually lack sufficient funding, whereas, *L2* presents the least importance for these factors. For "*Free Trial*", *L1* expectedly shows the highest importance as novice students typically lack sufficient information pertaining to software which requires them to test software prior to purchase. Similarly, the relatively low financial capabilities of students compared to this of graduated architects can explain the fact that *L1* perceives "*Payment plan*" to be of importance.

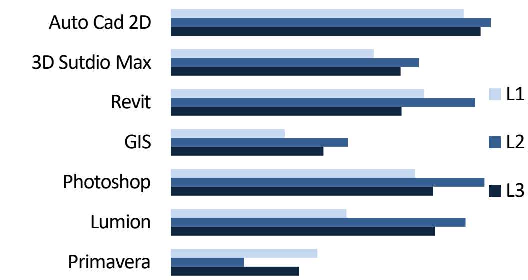
7.4. Correlational analysis

Pearson's correlation coefficient is calculated between all set of responses for each factor (Appendix B) to demonstrate trends in opinions and links between factors. Most factors have shown weak correlations. However, there were exceptions; the analysis shows a high positive correlation between "*Availability of learning material*" and "*Practicality*". The link between these factors is reasonable as understanding the tools and commands of a software is crucial for its practicality. Hence, the availability of sufficient learning materials is crucial for practicality. A moderate correlation can be observed between "*Payment plan*" and both, "*Cost*" and "*Free Trial*", which is rational as these factors revolve around the users' monetary condition. This suggests that users will value the ability to test software more highly the more it is costly.

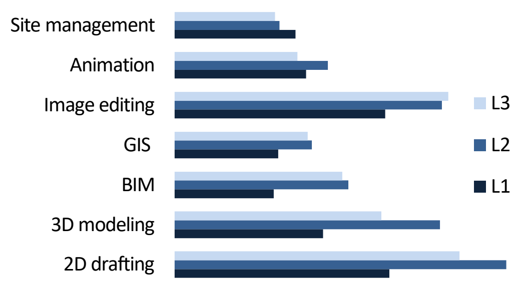
7.5. Software rating and frequency of use

As a complementary inquiry in the context of the study, the respondents rated their satisfaction with commonly used software (Appendix C), representing software functions used within the local architectural community. The respondents were instructed to consider the previous factors (in Table 1) to rate the software from 0% to 100% (with 0% signifying complete dissatisfaction and 100% representing complete satisfaction). The average software rating scores for each level are shown in **Error! Reference source not found.** (A). Distinctly, a pattern emerges across all software; In general, *L1* display the lowest satisfaction, *L2* display the highest, while satisfaction decreases slightly for *L3*; Skilled students are able to fully appreciate the capabilities of the software, while expert architects had more knowledge of software alternatives and could make more realistic evaluations, which can explain *L3*'s lower rating. Accordingly, it is reasonable to infer that architectural skills improve software comprehension, impacting software satisfaction. It is also apparent that software satisfaction is influenced by its relevance. For example, participants found that Autodesk® AutoCAD, 3DStudioMAX, and Adobe® Photoshop®, which are a better suit for architectural purposes, are more satisfactory than other less-pertaining software such as Primavera and GIS.

In this context, the relation between skill and software function is explored; the respondents were asked to express their frequency of using software functions (Appendix D) on a Likert scale (with 1 signifying no use and 5 signifying constant use). The average responses for each level are presented in **Error! Reference source not found.** (B). Contrary to previous findings, the chart shows that there is no definite correlation between respondents' skills and their frequency of software function usage.



(A)



(B)

Figure 3: (A) Average software rating. (B) Average software type frequency of use.

This confirms that function preferences are subjective depending on the user's study or role, not associated with architectural skills. However, it can also be seen that *L3* participants displayed the least frequency of software usage. This aligns with the fact that experienced architects focus on design and conceptualization, while beginners handle drafting and presentation.

8. Conclusions

It is clear that architectural skills do play a role in users' perception of software characteristics; as experience is gained, their software priorities will shift to better meet their professional needs, particularly regarding factors pertaining to practicality and cost. This fact should be taken into account when developing software; varying capabilities should be designed to meet the needs of different groups of users based on their skills. This could potentially impact both users' productivity and software sales. Naturally, this customization of software will not be possible for all software aspects as certain characteristics are standard and cannot be varied in capabilities. The study also highlights several findings; Factors contributing to productivity are more important for all user levels compared to other factors. Furthermore, experienced users favor practicality, while novice software users prefer easy learning. Also, novice users value software free-trials, whereas this is important for experienced users in the case of expensive software. Advanced architectural expertise helps users better understand software and access to funding influences the importance of hardware capabilities. Hence, Software for students should require less computational power as they may lack funding. Finally, the findings illustrate that users' skills do not necessarily affect preferred software functions, as this is subjective.

Based on the previous conclusions, several recommendations can be outlined:

- Users' requirements should not be considered collectively when designing a piece of software; users should be classified into groups based on their skills or expertise, which leads to practical and cost-effective features that address to the changing priorities of users as they gain skill. The goal is to ensure the software remains relevant and useful throughout users' professional growth.
- It is advantageous to develop multiple versions of software tailored to the skill levels of targeted users. It is also crucial to consider the cost implications associated with providing varying software capabilities.
- Software developers should offer simplified versions of their software as an introductory tool for beginners, while also providing accessible learning materials.
- Features that enhance practicality should be focused on particularly in software directed towards experts.
- Sufficient free-trial periods should be promoted, especially in the case of costly software.
- Architectural software developers must adopt productivity as their main focus. Facilitating features that support time-saving and effort reduction are of high priority.
- It is advantageous to create tools that aid software selection and comparison.

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Appendix (A): Respondents' answers

***L1* Responses**

ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Facility	9	10	9	8	9	10	10	10	8	3	10	9	7	9	10	10	10	9	7	9	8	10	6	9	10
Device requirements	9	8	8	9	9	7	10	9	8	8	8	10	7	9	10	10	10	9	10	10	7	10	10	10	10
Licensing	9	10	10	8	9	10	8	8	9	2	10	10	10	9	10	10	10	10	10	10	9	1	9	8	10
Ease of learning	9	10	6	6	9	10	10	6	6	1	10	7	9	10	10	10	10	9	8	10	9	1	7	10	10
Availability of learning materials	8	10	9	6	2	8	10	10	9	6	9	10	10	9	10	9	10	9	10	10	10	10	10	10	1
Practicality	9	10	10	9	7	9	10	9	6	6	10	10	9	8	10	10	10	10	10	10	9	7	10	8	1
Hardware requirements	7	8	8	9	9	7	8	10	6	8	10	10	6	10	10	6	10	9	7	10	8	8	2	8	10
Operating system	7	8	9	8	8	7	8	8	9	4	9	9	8	10	10	7	10	10	4	1	7	4	2	7	1
Stability	9	10	10	6	9	10	10	9	8	2	9	10	10	10	10	10	10	9	10	10	8	10	10	10	10
Cost	9	9	7	8	10	8	10	9	9	3	10	9	10	9	10	10	10	9	10	10	9	4	8	10	10
Free trial	7	10	9	9	10	9	9	10	8	3	10	7	9	10	1	10	10	6	10	10	8	10	1	10	10
Payment plan	9	10	10	8	10	9	10	7	8	2	10	10	9	9	10	10	10	9	10	10	10	2	10	10	10

***L2* Responses**

ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Facility	8	7	1	10	10	8	7	10	10	10	9	6	9	10	10	10	10	7	10	10	10	10	10	10	10	6	10	10	6	10	10
Device requirements	7	10	6	10	7	9	10	10	10	10	10	9	9	8	1	10	10	7	9	10	9	10	10	6	10	10	1	10	10	10	8
Licensing	10	7	1	10	6	4	10	9	8	8	8	9	8	10	10	8	10	10	10	10	10	8	9	6	10	9	10	10	10	10	10
Ease of learning	7	10	10	10	8	10	8	9	8	10	10	10	10	10	10	10	10	7	10	10	10	10	10	10	10	10	10	10	6	10	10
Availability of learning materials	10	10	10	10	9	8	8	10	9	10	9	9	8	10	10	10	10	7	10	8	10	10	10	10	10	8	7	10	10	10	10
Practicality	10	10	10	10	10	9	8	9	10	10	10	10	10	10	8	10	10	8	10	10	10	10	10	10	10	7	8	10	9	10	10
Hardware requirements	8	9	10	10	6	8	8	10	8	9	9	9	10	8	8	10	10	9	8	10	7	8	10	6	10	9	1	8	10	6	9
Operating system	6	7	10	10	8	3	9	10	7	10	10	7	10	8	1	4	6	6	8	7	7	9	8	7	10	9	6	6	6	6	8
Stability	10	10	10	10	9	10	10	10	8	10	10	10	10	10	10	7	10	10	10	3	10	10	9	10	10	9	10	10	10	10	10
Cost	10	8	10	10	10	8	8	10	8	1	9	9	9	9	10	10	10	10	8	10	8	7	1	9	10	10	10	8	10	6	10
Free trial	10	10	10	1	6	6	4	10	10	10	9	6	10	10	10	10	7	6	6	7	10	9	1	8	10	10	10	8	10	7	8
Payment plan	10	8	10	1	6	6	6	10	10	10	10	9	10	10	10	9	10	8	7	10	10	10	1	9	10	9	10	10	10	6	8

***L3* Responses**

ID #	1	2	3	4	5	6	7	8	9	10	11	12	13
Facility	10	10	9	10	9	9	4	8	8	7	10	8	5
Device requirements	7	7	8	10	10	9	6	5	8	8	7	9	6
Licensing	9	10	8	10	10	7	5	7	8	7	10	4	4
Ease of learning	9	10	10	10	8	8	8	8	8	6	10	6	6
Availability of learning materials	9	10	10	10	9	8	7	5	8	7	10	8	6
Practicality	10	10	8	10	10	8	8	7	8	6	10	3	8
Hardware requirements	4	8	9	9	7	7	5	4	8	7	7	8	5
Operating system	4	6	10	9	9	8	4	3	8	2	7	8	5
Stability	8	10	10	10	10	10	8	5	8	8	10	9	6
Cost	10	10	9	10	9	8	8	8	8	8	10	9	5
Free trial	4	6	10	10	6	10	8	6	8	7	7	7	7
Payment plan	9	9	9	10	6	9	6	8	8	2	7	8	8

Appendix (B): Pearson's correlation coefficient between factors.

	Ease of learning	Availability of learning material	Practical features	Hardware requirements	Operating system	Stability	Cost	Free trial
Availability of learning material	0.23							
Practicality	0.39	0.68						
Hardware requirements	0.16	0.13	0.08					
Operating system	0.20	0.29	0.30	0.29				
Stability	0.41	0.43	0.24	-0.09	0.22			
Cost	0.23	0.04	0.05	0.07	0.03	0.23		
Free trial	0.13	0.01	-0.08	0.08	0.07	0.20	0.23	
Payment plan	0.41	0.10	0.21	-0.01	0.12	0.24	0.53	0.53

A value of (0) indicates no correlation, (1) signifies a total positive correlation, and (-1) signifies total negative correlation.

Appendix (C): Software rating

***L1* Responses**

ID	Auto Cad 2D	3D Studio	Revit	GIS	Photoshop	Lumion	Primavera
1	70%	80%	80%	70%	90%	90%	80%
2	20%	40%	10%	10%	40%	30%	10%
3	70%	70%	40%	-	60%	20%	70%
4	90%	60%	80%	40%	50%	60%	80%
5	70%	10%	70%				
6	100%	90%	100%		60%	70%	
7	100%	30%	100%	10%	100%	80%	10%
8	100%						
9	50%						
10	60%	10%	10%	10%	80%	10%	10%
11	70%	90%	70%		90%		
12	70%		90%		50%		
13	80%	80%	80%	50%	90%	50%	50%
14	100%	10%	100%	10%	100%	10%	10%
15	100%						
16	70%				10%		
17	90%			50%			
18							
19							
20	100%	70%		30%	100%		
21	100%						
22	90%						
23	90%						
24	80%				10%	60%	
25	70%	80%			70%		
Avg.	80.0	55.4	69.2	31.1	66.7	48.0	40.0

***L2* Responses**

ID	Auto Cad 2D	3D Studio	Revit	GIS	Photoshop	Lumion	Primavera
1	80%	60%	80%			70%	
2	100%	90%	80%		100%	90%	
3	80%	60%			90%		
4	90%	90%	70%		90%	70%	
5	80%	70%	100%		80%	90%	
6	90%		70%		70%		
7	90%	40%	70%		90%	50%	
8	90%		90%		90%	90%	
9	90%	50%	50%	10%	70%	50%	10%
10	100%	40%			80%		
11	80%	80%	50%		80%	80%	
12	80%	50%	90%		70%		
13	90%	70%	50%		100%	60%	
14	100%	40%	90%	10%	60%	50%	10%
15	100%		90%		90%	90%	
16	30%		90%		70%		
17	90%		80%		90%		
18	100%		90%	40%	100%	100%	
19	80%		80%		50%	100%	
20	90%	90%	100%		100%	80%	
21	80%	60%	90%		100%	100%	
22	100%	70%	90%	70%	100%	100%	
23	90%		70%		90%		
24	90%	80%	100%	60%	60%	30%	10%
25	100%	100%	80%		100%	100%	
26	100%	90%	100%		100%	100%	
27	80%	30%	90%		80%		
28	90%		100%		100%		
29	70%	80%	80%		80%	90%	
30	80%	80%	90%		90%	100%	
31	100%	70%	100%	100%	100%		50%
Avg.	87.4	67.7	83.1	48.3	85.7	80.5	20.0

***L3* Responses**

ID	Auto Cad 2D	3D Studio	Revit	GIS	Photoshop	Lumion	Primavera
1	100%	90%	70%	10%	80%	90%	10%
2	100%	50%	50%	30%	30%	30%	10%
3	80%	50%	70%	60%	100%		
4	100%	50%			70%	90%	
5	100%	80%	80%		100%	70%	
6	100%	50%	50%		50%		
7	80%	30%	60%		50%	70%	
8	0%	80%	90%		80%	80%	
9	90%	70%	90%	90%	70%	40%	70%
10	100%	80%			100%	100%	
11					60%		
12	80%		20.00%	10.00%	70%		
13	80%	60%	50%	50%		80%	50%
Avg.	84.2	62.7	63.0	41.7	71.7	72.2	35.0

(Shaded cell) Respondent does not use this piece of software, no rating given

Appendix (D): Frequency of use

***L1* Responses**

ID	2D drafting	3D modeling	BIM	GIS	Image editing	Animation	Site management
1	4	3	1	1	4	1	1
2		2	1	1	3	2	1
3	3	1	1	1	1	1	1
4	3	1	1	1	1	1	1
5	4						
6	4	3	1	3	5	2	3
7	3						
8	2	1	1	1	1	1	1
9	4	1	1	2	3	1	1
10	2	1	1	1	1	1	1
11	4						
12	1	1	1	1	5	3	2
13	3	3	1	1	2	4	2
14	3	3	1	1	4	2	1
15	3	1	1	1	1	1	1
16	3	2	1	1	4	2	1
17	1	1	2				
18	3	1	1	1	5	1	1
19	5	1	1	1	3	1	1
20	4	3	2	2	4	3	3
21	3	2	1	1	3	1	1
22	3	4	4	3	3	4	5
23	3	5	4	4	2	2	4
24	2	4	1	1		2	1
25	1	1	1	1	3	2	2
Avg.	3	2	1	1	3	2	2

***L2* Responses**

ID	2D drafting	3D modeling	BIM	GIS	Image editing	Animation	Site management
1	4	5	4	4	4	4	3
2	5	4	3	2	4	5	1
3	3	3	1	1	3	3	1
4	5	5			3		
5	4	3	1	1	3	1	2
6	3	4	4	2	5	4	1
7	4	5	2	1	4	3	1
8	5	4	3	3	2	2	2
9	5	4	1	1	5	1	1
10	5		2	2	4	1	1
11	4	3	2	1	4	2	1
12	5	3	3	2	3	1	2
13	5	4	1	1	3	4	1
14	5	4	4	3	5	1	1
15	4	3	2	3	4	1	1
16	4	5	1	2	3	1	1
17	4	3	3				
18	5	4	4	3	4	3	2
19	5	3	2	4	5	1	3
20	5	3	3	2	3	1	2
21	4	3	3	2	3	2	3
22	5	3	2	2	4	2	1
23	5	2	1	1	4	1	1
24	5	3	2	1	2	1	1
25	5	4	3	1	3	2	1
26	5	4	4	1	3	3	2
27	5	5	1	2	5	1	1
28	5	2					
29	5	5	4	2	5	5	1
30	4	3	1	1	3	1	1
31	5	4	2	2	4	2	1
Avg.	4	5	4	4	4	4	3

***L3* Responses**

ID	2D drafting	3D modeling	BIM	GIS	Image editing	Animation	Site management
1	5	4	1	1	4	1	1
2	4	3	4	5	4	2	1
3	3	4	5	1	2	4	1
4	4	4	3	2	3	1	1
5	3	1	3		3	1	1
6	5	2	1	1	5	1	1
7	5	3	1	1	4	1	1
8	3	2	2	2	4	1	1
9	5	3	2	4	5	2	5
10	5	5	3	1	5	5	1
11	1	1	1	1	4	1	1
12	4	2	2	2	5	1	1
13	4	3	2	1	1	1	2
Avg.	4	3	2	2	4	2	1

(Shaded cell) Respondent does not use this type of software, no response given.