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# **The art of selecting PhD students: Combination of Bibliometric and AHP Approach**

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## **Abstract**

For the PhD guide or the advisor selecting the accurate PhD scholar is the most elephantine task. It actually requires an art for the perfect selection; as the length, breadth, depth and volume of PhD work is spread across the years and this relationship between the scholar and the guide should start and flourish positively for the immense experience throughout the PhD process. Hence it was essential to understand bibliometric details including how many researchers have already published their contributions in the form of papers and patents, in the Scopus database. In addition to the bibliometric details, in this study, we also have incorporated the Analytical Hierarchical Process (AHP) model, based on primary and secondary characteristics related to aspiring PhD candidate(s). These characteristics are taken from the literature as well as based on the experience of various PhD guides, over the years of mentoring students. Hence this paper not only discusses the bibliometric details related to the topic but also provide guidelines for appropriate selection of the PhD student.

**Keywords:** Characteristics of PhD students, Selection of PhD students, AHP, Scopus db, Scholars, Researchers.

## **1. Introduction**

Every aspiring PhD or research scholar is a bundle of varied attributes or characteristics. Same is the case with PhD guides too. It will be useful to know how to select PhD student, as PhD is a lifelong journey or path to walk along with the supervisor. It's a kind of lifetime commitment and value-full relationship which needs to be nurtured forever. And the reason behind calling it as commitment is solely because this relationship required to produce many tangible outcomes including good quality research papers in high indexed journals, book chapters, patent(s), funded project(s) etc. to name a few. To achieve all these or many more beneficial details, its necessary to handpick the candidate which has a rigor for the research. To predict these embedded details of the research scholar's personality it is essential to have a rubrics kind of stuff before the selection of the candidate. This paper is the basic experiment with few matrices and details which may be useful for the supervisors to select the most apt candidate for their research arena. This paper is not panacea for this world-known predicament, but will definitely help in initial scrutiny of the candidates. Outline of this paper is section 1 is introduction, followed by related work in section 2, in section 3 bibliometric review related papers from Scopus db, section 4 presents AHP model for selection of PhD students, section 5 conclusion followed by reference in section 6. Last section contains references used to build this paper.

## **2. Related Work**

All the papers starting from 1961 to 2020 are considered for this valuable study focusing only Scopus database papers. The following section discusses the contribution by various authors related to the considered important keywords.

(Liu et.al 2019) Despite the fact that the psychological wellness status of doctoral understudies merits consideration, couple of researchers have focused on elements identified with their emotional well-being issues. The authors have planned to research the predominance of sorrow and nervousness in doctoral understudies and inspect conceivable related components. The authors have further intended to survey in the case of tutoring connections intercede the relationship between research self-adequacy and sorrow/tension.

An inter-sectional investigation was directed with 325 PhD understudies at therapeutic college. The survey about Patient Health 9 and comprehensive Anxiety Disorder 7 scale utilized to evaluate gloom as well as tension. The Self-Efficacy Research Scale utilized to gauge apparent capacity for satisfying different research-specific exercises. The Advisory Working Alliance Inventory-understudy adaptation utilized for survey coaching connections. Direct progressive relapse examinations were performed to decide whether any components were essentially connected with sorrow and tension. Asymptotic and resampling techniques were utilized to analyze in the case of coaching assumed an interceding job.

Around 23.7% of members gave indications of sadness, and 20.0% gave indications of tension. Evaluation in school was related with the level of melancholy. The recurrence of gathering with a coach, trouble in doctoral article distribution, and trouble in adjusting work–family–doctoral program was related with both the degree of discouragement and nervousness. Additionally, examine self-viability and coaching connections had negative associations with levels of sorrow and tension. We additionally found that coaching connections intervened the relationship between's exploration self-adequacy and discouragement/nervousness. The creators took a shot at the accompanying arrangement of watchwords: emotional wellness, real burdensome issue, summed up nervousness issue, Advisory Working Alliance, examines self-adequacy, doctoral understudies.

(Elisabeth 2017) Around 33% of Ph.D./Doctoral understudies be in danger to either have or build up a typical mental issue like misery, an ongoing report reports. Despite the fact that these outcomes originate from a little example—3659 understudies at colleges in Flanders, Belgium, 90% of whom were concentrating technical disciplines and sociologies—they are in any case a significant expansion to the developing writing about the commonness of psychological well-being issues in the scholarly community. One important input for logical students those are battling for these difficulties, compose co-creators Katia Levecque and Frederik Anseel of Ghent University in an email to Science Careers, is that "you are not the only one." Ahead of that, the creators energize doctoral understudies need to acknowledge that it's so imperative to deal with themselves. "Emotional well-being issues can form into genuine dangers to one's prosperity and profession, and can have adverse outcomes in the long haul," they compose. Thus, in case your battling, it is imperative to "[s]eek expert assistance or look for assistance in your own condition, regardless of whether you believe it's most likely an impermanent thing."

(Balasubramanian et.al 2012) The point of this investigation was to assess the psychological well-being of Indian orthodontic postgraduate orthodontic understudies through survey of degree of normal three pessimistic full of feeling states: gloom, uneasiness, along with stress. 330 understudies for postgraduate were examined out of which 32 Indian dental universities crosswise namelessly finished the short form DASS21 i.e. Depression Anxiety Stress Scale. The factual examination consists of rundown measurements, non-parametric tests for inter-group correlations, also calculated relapses for assessing the impact related to age, sexual orientation, study year, as well as conjugal status of these psychological conditions. On contrary with overall public, the understudies realized somewhat raised degrees about melancholy as well uneasiness ( $11 \pm 5.1$  and  $8.2 \pm 4.1$ , separately) also a tolerably raised mental pressure of  $22 \pm 5.2$  degree. A moderately or larger amount of existing together manifestations where all the three full of feeling conditions were seen in 15.8% of the understudies. Understudies related to female detailed larger despondency than guys and were 2.5 times bound to encounter moderate or higher level gloom. Understudies for first-year displayed low levels for each of the three states as that of in the second as well as third years and had lesser chances than third-year understudies to build up a modest or larger amount for any of these three full of feeling states. Marriage could be a notable buffering latent against every one of these three states. Obviously outcomes show a problematic degree considering emotional wellness in these understudies relating to postgraduate of the claim to fame and the want to get better their psychological flexibility and the scholarly atmosphere.

(Kitia et.al 2017) Research arrangement onlookers are progressively worried about the substantial effect of momentum scholastic operational conditions on emotional wellness, especially in doctoral/PhD understudies. The point of present examination is triple. To begin with, we survey the commonness of emotional wellness issues in a delegate test for PhD understudies in Flanders, Belgium ( $N = 3659$ ). Secondly, we contrast doctoral understudies with three different examples: (I) profoundly instructed for all inclusive community ( $N = 769$ ); (II) exceptionally taught representatives ( $N = 592$ ); and (III) advanced educational understudies ( $N = 333$ ). Third one evaluation of those hierarchical variables identifying the job of PhD understudies anticipating emotional well-being status. Results dependent on 12 emotional wellness indications (GHQ-12) demonstrated up to 32% of PhD understudies are in danger to have or build up the typical mental issue, particularly sorrow. This gauge was altogether higher than those acquired in the examination gatherings. Authoritative approaches were altogether connected with the

commonness of emotional wellness issues. Particularly work-family interface, work requests and employment control, the chief's authority style, group basic leadership culture, and impression of a vocation outside scholarly community are connected to psychological wellness issues. Catchphrases: Mental wellbeing, GHQ-12, Work association, Psychosocial working conditions, PhD scholars.

(Nature 2011) In certain nations, like the United States and Japan, individuals prepared at extraordinary cost and length be specialists go up against a decreasing number of scholarly employments, and a mechanical area incapable to take up the leeway. Supply has overwhelmed request and, albeit couple of PhD holders end up jobless, it isn't evident that going through years verifying this abnormal state capability is justified, despite all the trouble for an occupation as, a secondary teacher. In different nations, for example, India and China, are the growing economies adequately quick to utilize every one of the PhDs they can wrench out, and that's only the tip of the iceberg — however the nature of the alumni isn't reliable. Just a couple of countries, like Germany, are effectively handling this issue using reclassification of PhD as preparing for abnormal state vacancies in vocations exterior to scholarly community. Here, world looks at alumni training frameworks in different conditions of wellbeing.

(Susan 2009) Sixty doctoral understudies and 34 employees were met in offices distinguished as having increasing as well as diminishing PhD understudy finishing rate at one of the establishment in the United States so as to look at the social settings and encouraging structures that encourage or upset PhD understudy consummation. This research paper plots distinctions about understandings of PhD understudy steady loss through job and through office utilizing ascription hypothesis. Suggestions for strategy, practice, and further research are incorporated. Catchphrases: Doctoral understudies, wearing down, attribution hypothesis.

(Jenny et.al 2011) There is a variety as far as how scientists see the idea of research work. Past research has principally taken a gander at the individuals from the scholarly world that as of now have set up themselves in the academic network. We planned for investigating the manners by which doctoral understudies apparent their theory venture and additionally, the dealings of these observations relating to prosperity and commitment towards study. The members were 669 doctoral understudies from medication, humanities, and conduct sciences from a Finnish college who addressed a survey, including both organized and open-finished inquiries. The examination was spilt into subjective and non-subjective information. The outcomes showed understudies'

discernments fluctuated, running from seeing the theory as an item to review it as a procedure of creating aptitude. Further, the outcomes showed that seeing work on the proposition as a procedure was most profitable as far as experienced prosperity and study commitment. The authors focused on following keywords in their research and they are: PhD-education, personal-meaning, well-being, study commitment.

The rest of the paper is organized in the following manner. The immediate next section is all about the magnificence of bibliometric details, followed by the graphical analysis of various publication details, discussion of AHP models in the next section and then the conclusive summary with future direction related to this study.

### 3. Bibliometric Review of Research Papers from Scopus Database

234 documents from Scopus database was extracted matching the given set of keywords related to PhD scholar's selection. This Bibliometric study showcases the graphical analysis related to the citation details, universities which are involved in publishing the research related to this most essential topic(s), countries, funding agencies and subject areas are some other graphical analysis discussed in this review paper.

This review is undertaken and Analytical Hierarchical Processing (AHP) model is build to suggest a model with primary and secondary attributes related to selection of PhD scholars, based on authors' knowledge and experience. The primary aim of this study is to produce quality PhD research work, reduce the degree of leaving the PhD programs worldwide, as well as providing peace to both guide as well as the scholar, as the selection is carefully and thoughtfully made.



Fig1 shows citation overview details of publications for last 4 years - citations in year 2018 are more and are less in 2019. Citations in year 2015 and 2016 are almost same. This indicates that in 2018 this research is most referred (Source: [www.scopus.com](http://www.scopus.com), accessed on 20<sup>th</sup> September 2019)

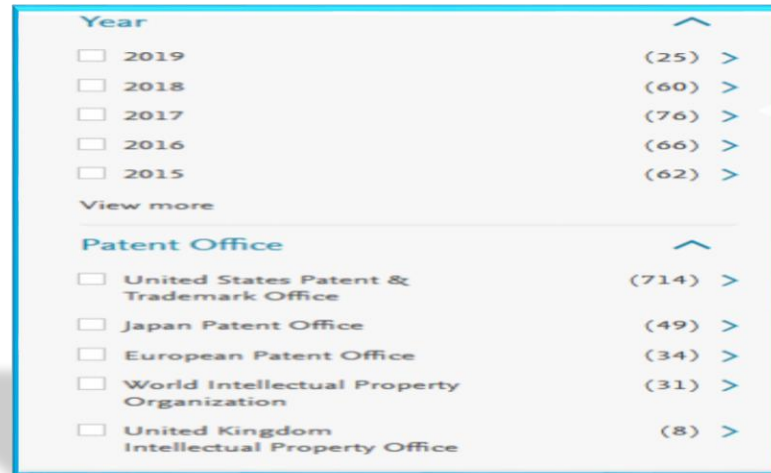


Fig 2 shows the details of patents filled and published already related to emotional response, expressions, prioritize, feature space, clusters, methods & systems for assisting researchers, etc., 2,655 Document results that cite selected 234 documents (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)

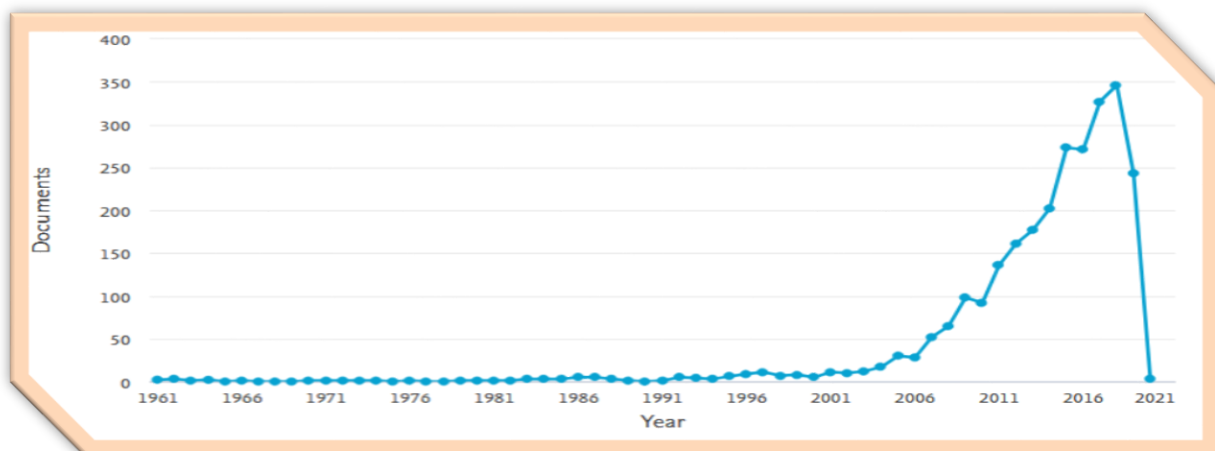


Fig 3 shows citation of “how to select PhD students” related papers, its visible that even though the papers are published since 1961, but the citation of such published work started picking up from 2006 onwards (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)



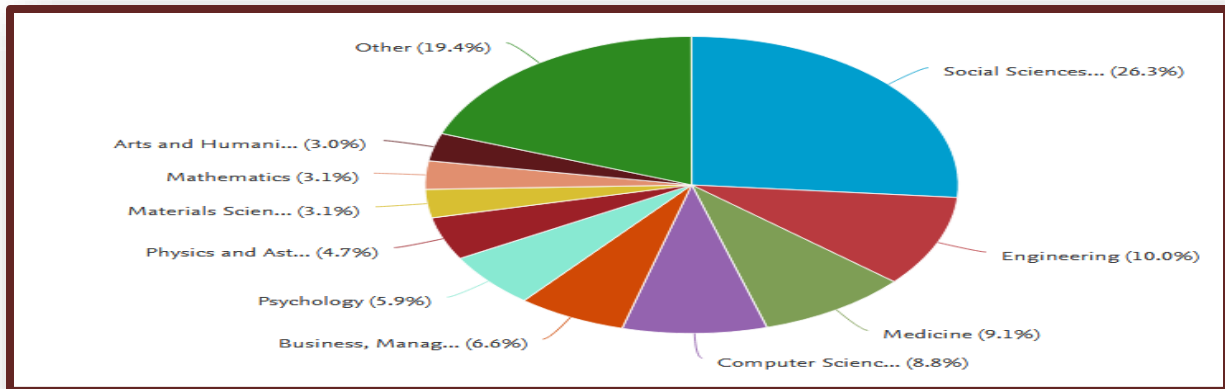


Fig 4 shows document citation trend from various subject areas, ranging from 1961 to 2020 – Social Sciences leading followed by others and Engineering (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)

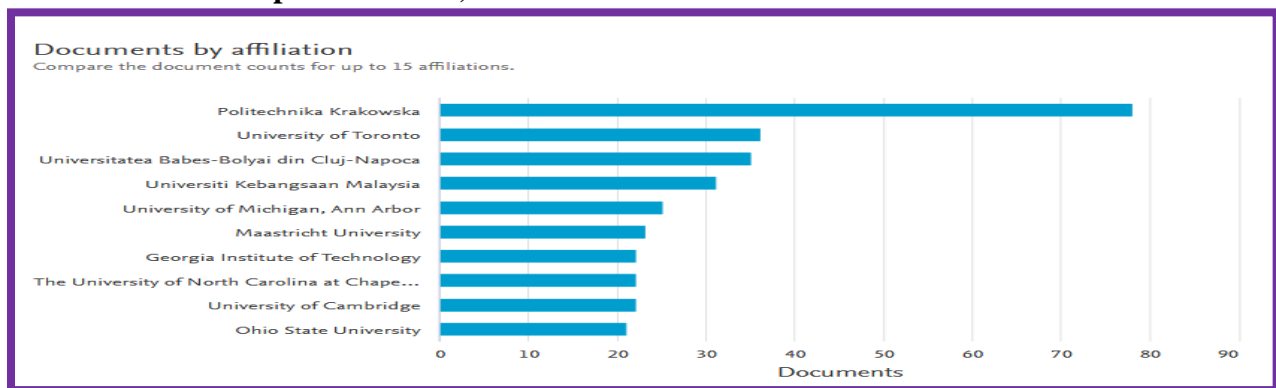


Fig 5 shows citation trend of various universities and institutions – Politechnika Krakoska is leading followed by University of Toronto and Universitatea Babes-Bolyai din cluj-Napoca (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)

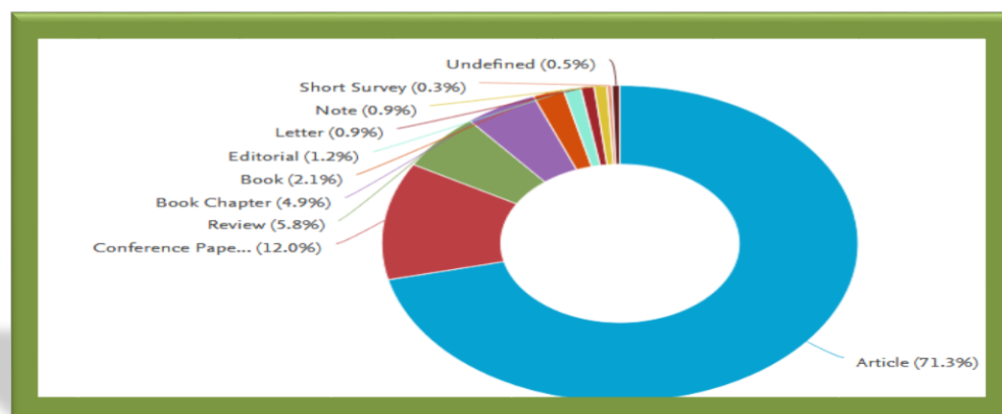
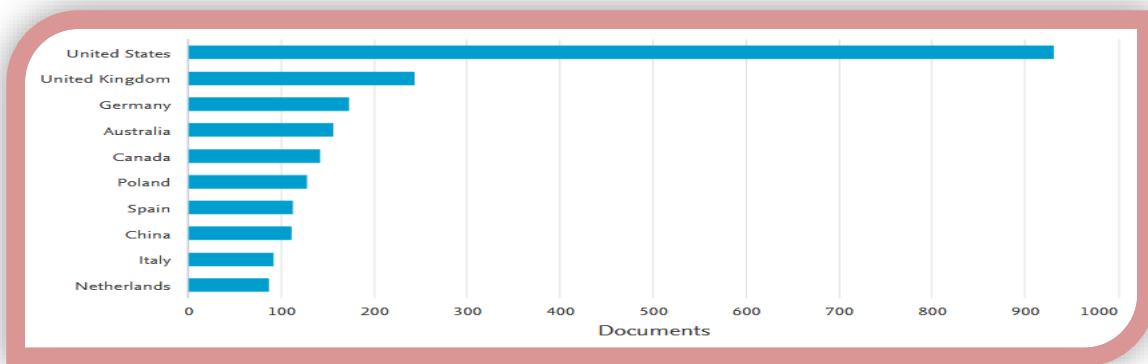
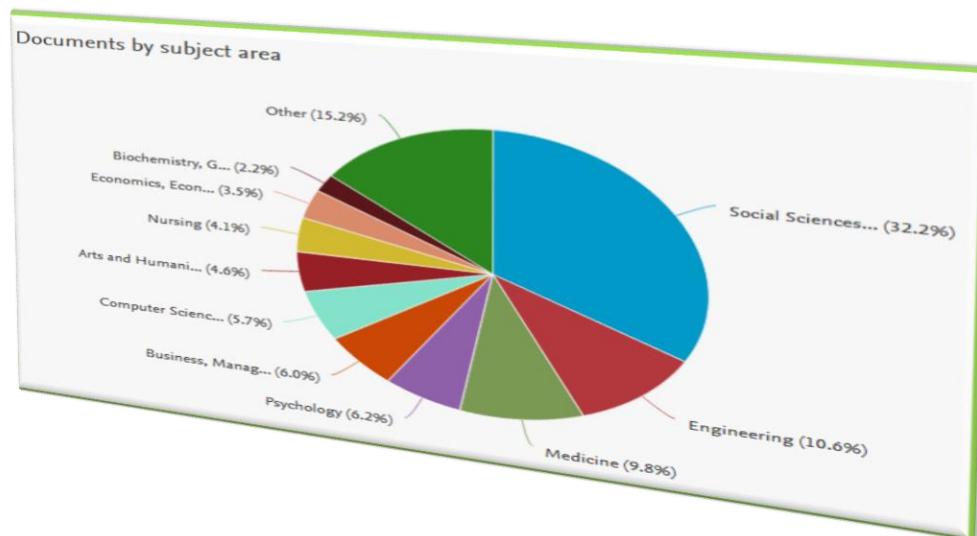


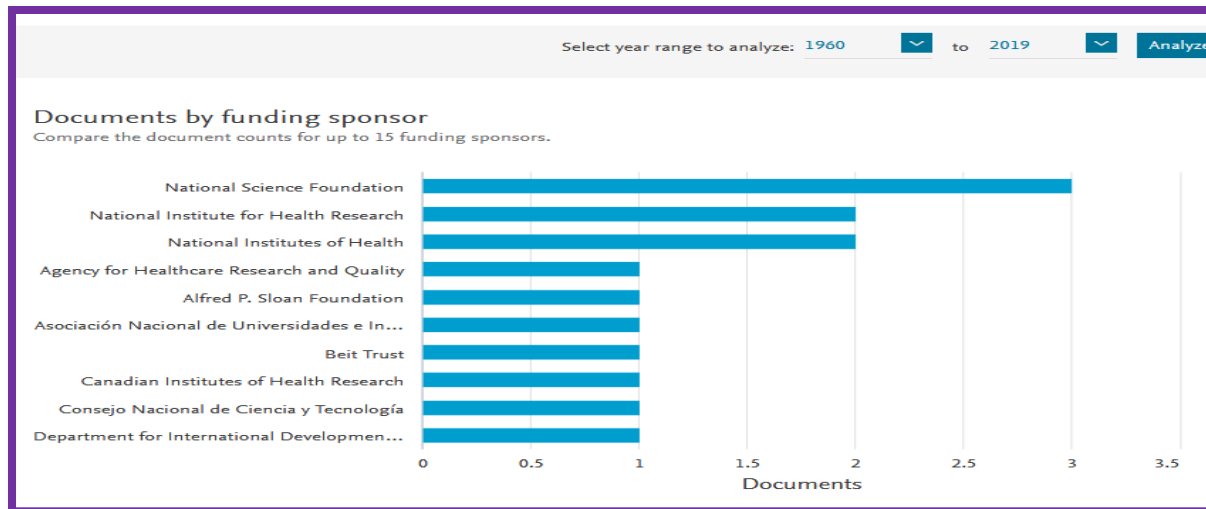
Fig 6 shows the trend of citing papers already published in Scopus db, in varied types of documents – articles count is more (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)



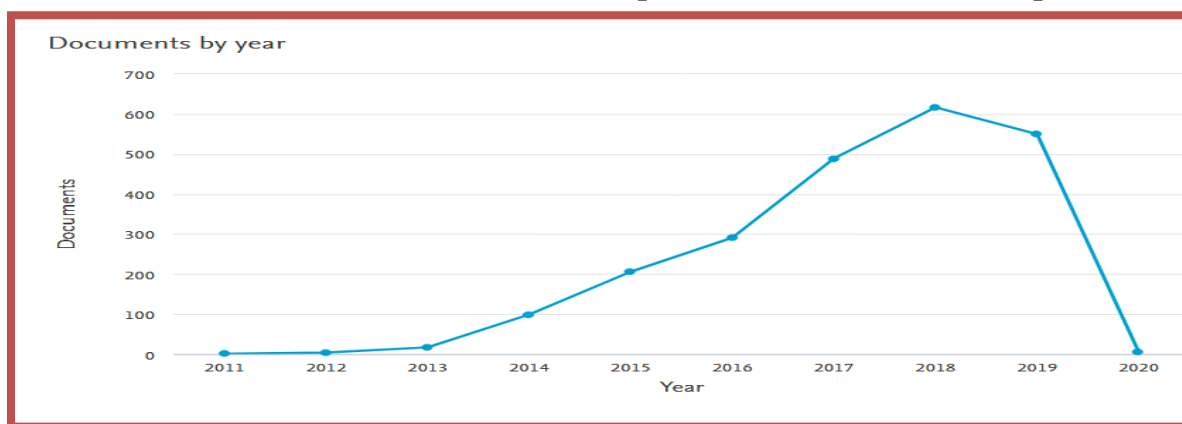
**Fig 7 shows country specific citation trend from 1961 to 2020 – United States leading followed by United Kingdom and Germany (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)**



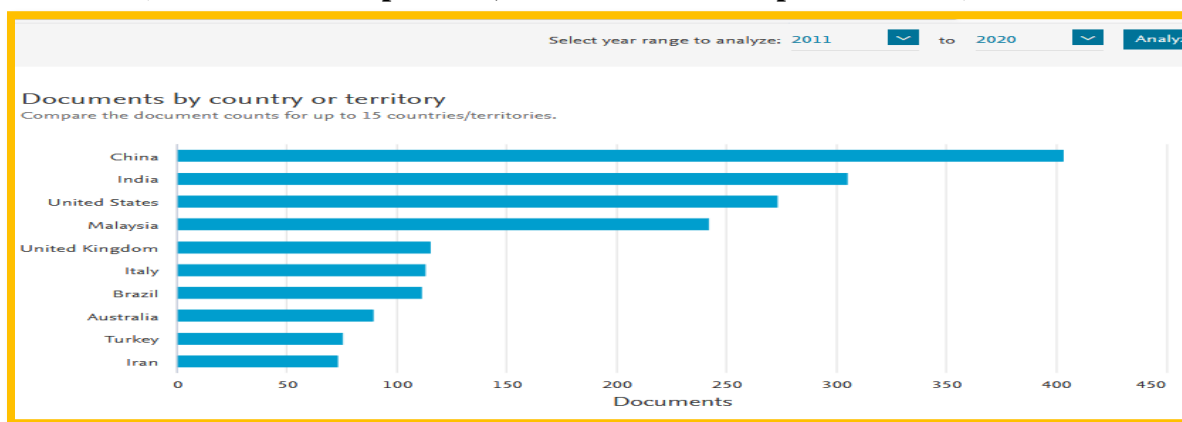
**Fig 8 shows the various subject areas where the papers are published related to selection of PhD students. The figure shows that research is going on in all these depicted areas and in all these areas PhD-Guides are thinking about “how to select PhD student?” (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)**



**Fig 9 shows funding agency details those who have given financial assistance for such useful research work – National Science Foundation is leading followed by National institute for health research (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)**



**Fig 10 shows citation analysis of secondary documents from Scopus db – more in year 2018 and 2019 (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)**



**Fig 11 shows the country territory of secondary documents – China is leading followed by India and United States (Source: [www.scopus.com](http://www.scopus.com), accessed on 20th September 2019)**

#### 4. Analytical Hierarchical Processing (AHP) model for selection of PhD students

(Wikipedia, 2019) AHP is a multi-attribute, multi-alternative mathematical method for making complex decisions. (Wikipedia, 2019), (Suhas et al 2015) AHP is useful for making comparisons among qualitative and quantitative attributes. AHP successfully applied nearly in every domain like selection of nuclear power plants, best scenario for reducing climate change, faculty selection for a particular department, cross-country petrol pipeline operation risk, recommending ice cream to diabetic patients and watershed management strategies etc (Wikipedia, 2019). (ahp-calc.php, 2019) Now-a-days, few online links are available by using which AHP calculations can be done easily. AHP's prominent presence in the literature can be easily observed through bibliometric study carried in this study paper. AHP follows five steps process model as given below:

- 1] Hierarchy modeling
- 2] Priorities establishment
- 3] Judgment synthesis about overall priorities of hierarchy
- 4] Consistency check and
- 5] Decision formulation

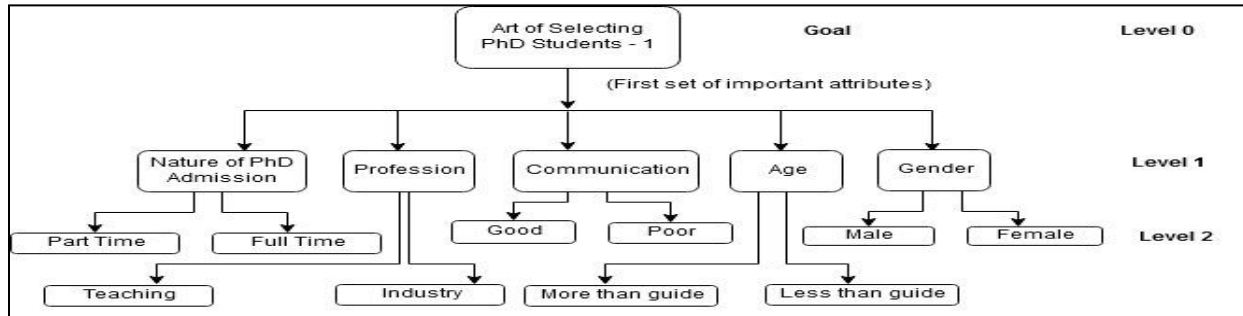
(Saaty et al, 1988) Numerical ratings from 1 to 9 are used to compare among attributes at different levels in the hierarchy along with considered alternatives. This rating is called as called as "Saaty's AHP scale". The below mentioned table 1 shows details about this scale.

**Table 1 Saaty's AHP scale**

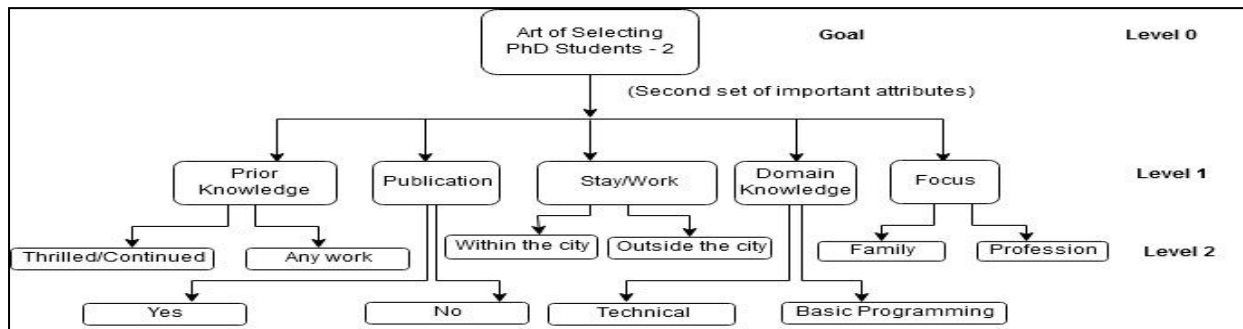
<b>Sr. No.</b>	<b>Numerical Rating</b>	<b>Interpretation</b>
1	1	Equally important
2	3	Somewhere important
3	5	Much important
4	7	Very much important
5	9	Absolutely important
6	2,4,6,8	Intermediate important

After looking at details about AHP methodology, there is need to discuss to discuss about novel formulation of AHP about selection of PhD students. The first step is hierarchy modeling – here two sets of attributes are considered viz. first set of important attributes and second set of important attributes. There are five first and second set of important attributes. Each of these five

attribute are then followed by ten secondary attributes. Below mentioned figures show first and second level of important attributes and their secondary attributes respectively.



**Fig. 12 First set of important attributes for selection of PhD students**



**Fig. 13 Second set of important attributes for selection of PhD students**

After looking at hierarchy modeling, below mentioned tables show priorities establishment for selected set of attributes. Table 2 to 5 shows prioritization among first & second set important attributes, their secondary attributes respectively. The color coding used in the columns A and B of table 2 to 5 shows number of comparisons need to be performed of A with respect to B. The yellow color shows importance among the compared attributes by establishing relevance with scale in table 1. In all 130 comparisons are performed for considered total of 30 attributes from first and second set of important attributes for selection of PhD students. These 130 comparisons are evident from table 2 to 5. Importance using the Saaty's AHP scale assigned to first and second set of PhD student's selection attributes by considering the carried out literature survey. Third step is judgment synthesis; this step is linked with consistency check. If consistency check is below 10% for considered levels of first and second set of attributes then it cross verifies that the judgments synthesized through priority establishment step. Table 6 to 9 show consistency checks for considered levels of first and second set of important attributes for PhD student's selection. It is evident from these tables that consistency check is below 10%. Fig. 14 to 17 shows decision formulation in terms of ranking graphs obtained on the basis table 2 to 9. All

calculations in table 2 to 9 are performed using <https://bpmmsg.com/ahp/ahp-calc.php>. Table 10 summarizes decision formulation for considered levels of first and second set of attributes related to selection of PhD students. It is clear from table 10 that candidate with full time admission, can be able to do any PhD work, from teaching profession, with prior publications, having good communication and staying/working within the city is the best choice for PhD.

**Table 2: Priorities establishment for level 1 – first set of important attributes for selection of PhD students (10 comparisons)**

[illegible]

**Table 3: Priorities establishment for level 1 – second set of important attributes for selection of PhD students (10 comparisons)**

[illegible]

**Table 4: Priorities establishment for level 2 – first set of important attributes for selection of PhD students (45 comparisons)**

[illegible]



35	Within the city	Profession								
36	Outside the city	Technical								
37	Outside the city	Basic Programming								
38	Outside the city	Family								
39	Outside the city	Profession								
40	Technical	Basic Programming								
41	Technical	Family								
42	Technical	Profession								
43	Basic Programming	Family								
44	Basic Programming	Profession								
45	Family	Profession								

**Table 6: Consistency check for level 1 – first set of important attributes for selection of PhD students**

Consistency check for level 1 – first set of important attributes									
	Priority	Rank	+	-	1	2	3	4	5
Nature of PhD Admission	43.80%	1	10.60%	10.60%	1	2	3	7	9
Profession	29.40%	2	9.30%	9.30%	0.5	1	2	8	6
Communication	17.80%	3	5.50%	5.50%	0.33	0.5	1	3	8
Age	5.50%	4	1.20%	1.20%	0.14	0.12	0.33	1	2
Gender	3.50%	5	1.20%	1.20%	0.11	0.17	0.12	0.5	1
Number of matrix comparisons =	10			Principle Eigen Value =	5.169				
Consistency check =	3.70%			Eigen vector solution =	5 iterations, delta = 1.4E-8				

**Table 7: Consistency check for level 1 – second set of important attributes for selection of PhD students**

Consistency check for level 1 – second set of important attributes									
	Priority	Rank	+	-	1	2	3	4	5
Prior Knowledge	46.50%	1	18.60%	18.60%	1	3	4	6	4
Publication	27.00%	2	11.20%	11.20%	0.33	1	3	6	3
Stay/Work	12.70%	3	3.80%	3.80%	0.25	0.33	1	2	3
Domain Knowledge	7.30%	4	3.00%	3.00%	0.17	0.17	0.5	1	2
Focus	6.60%	5	3.10%	3.10%	0.25	0.33	0.33	0.5	1
Number of matrix comparisons =	10			Principle Eigen Value =	5.338				
Consistency check =	7.50%			Eigen vector solution =	6 iterations, delta = 9.60E-09				

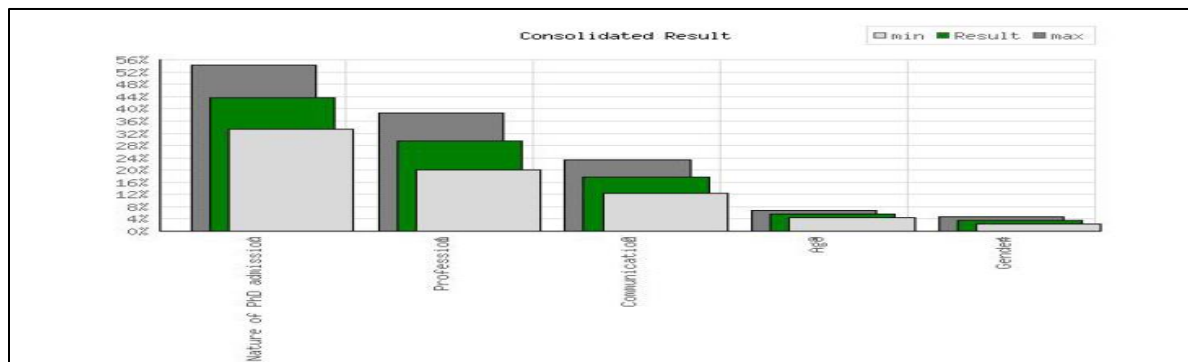


**Table 8: Consistency check for level 2 – first set of important attributes for selection of PhD students**

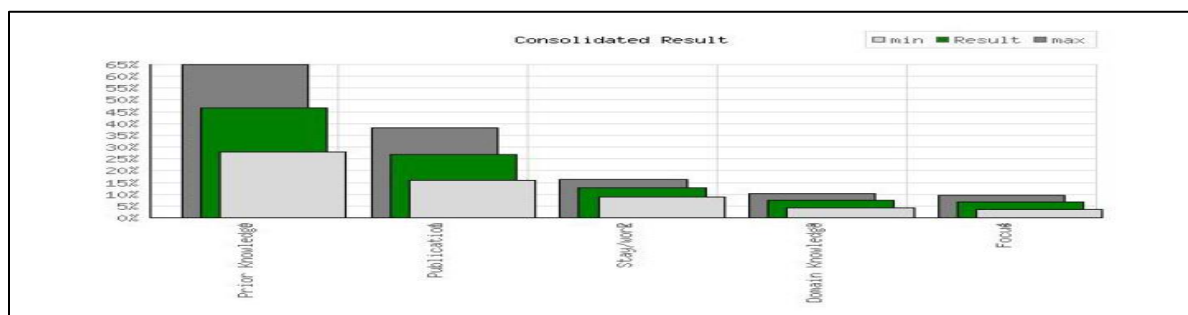
Consistency Check - Level 2 of first set of important attributes															
	Priority	Rank	+	-	1	2	3	4	5	6	7	8	9	10	
Part Time Admission	21.60%	2	10.70%	10.70%	1	1	1	6	4	6	3	5	8	9	
Full Time Admission	24.30%	1	12.40%	12.40%	1	1	2	5	7	3	6	4	9	8	
Teaching	20.60%	3	10.60%	10.60%	1	0.5	1	4	6	7	4	7	4	6	
Industry	9.20%	4	5.70%	5.70%	0.17	0.2	0.25	1	2	3	5	2	7	4	
Good Communication	7.30%	5	4.30%	4.30%	0.25	0.14	0.17	0.5	1	4	2	3	4	6	
Poor Communication	4.90%	7	2.90%	2.90%	0.17	0.33	0.14	0.33	0.25	1	1	3	6	2	
More than guide	4.90%	6	2.20%	2.20%	0.33	0.17	0.25	0.2	0.5	1	1	2	3	6	
Less than guide	3.60%	8	1.60%	1.60%	0.2	0.25	0.14	0.5	0.33	0.33	0.5	1	4	3	
Male	1.80%	9	1.10%	1.10%	0.12	0.11	0.25	0.14	0.25	0.17	0.3	0.25	1	1	
Female	1.80%	10	0.70%	0.70%	0.11	0.12	0.17	0.25	0.17	0.5	0.2	0.33	1	1	
Number of matrix comparisons =	45							Principle Eigen Value =	11.28						
Consistency check =	9.60%							Eigen vector solution =	7 iterations, delta = 1.50E-08						

**Table 9: Consistency check for level 2 – second set of important attributes for selection of PhD students**

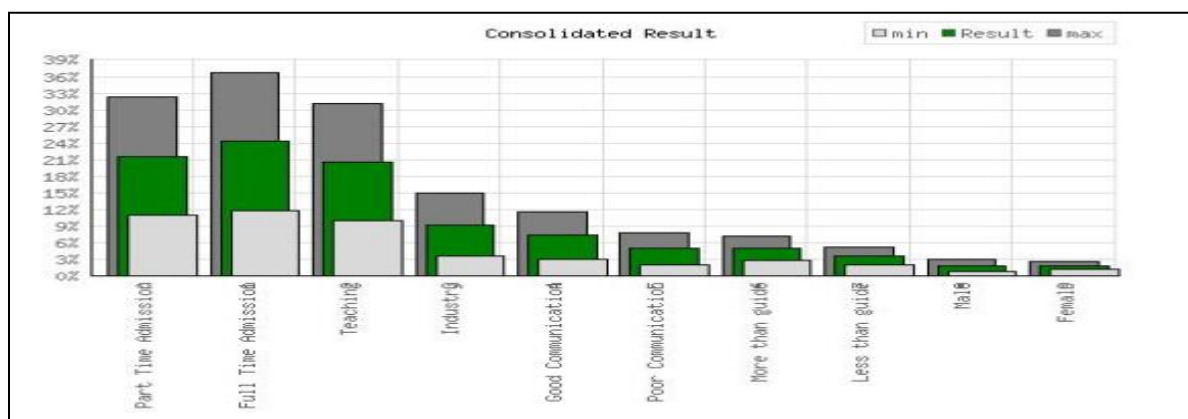
Consistency Check - Level 2 of second set of important attributes														
	Priority	Rank	+	-	1	2	3	4	5	6	7	8	9	10
Thrilled/ Continued	22.30%	2	7.00%	7.00%	1	1	2	4	3	7	6	4	9	7
Any work	28.30%	1	18.70%	18.70%	1	1	5	3	7	4	6	6	8	8
Publication - Yes	15.50%	3	6.20%	6.20%	0.5	0.2	1	2	2	5	6	7	8	7
Publication - No	8.80%	4	2.40%	2.40%	0.25	0.33	0.5	1	1	3	2	4	7	4
Stay/Work - within	8.30%	5	2.80%	2.80%	0.33	0.14	0.5	1	1	3	2	4	7	3
Stay/Work - outside	5.00%	6	2.80%	2.80%	0.14	0.25	0.2	0.33	0.33	1	2	3	6	1
Domain Knowledge - Technical	4.80%	7	2.00%	2.00%	0.25	0.17	0.17	0.5	0.5	0.5	1	3	5	3
Domain Knowledge - Basic Programming	3.10%	8	1.70%	1.70%	0.17	0.17	0.14	0.25	0.25	0.33	0.33	1	4	3
Focus - Family	1.50%	10	0.80%	0.80%	0.11	0.12	0.12	0.14	0.14	0.17	0.2	0.25	1	1
Focus - Profession	2.30%	9	1.00%	1.00%	0.14	0.12	0.14	0.25	0.33	1	0.33	0.33	1	1
Number of matrix comparisons =	45							Principle Eigen Value =	10.98					
Consistency check =	7.30%							Eigen vector solution =	6 iterations, delta = 4.80E-08					



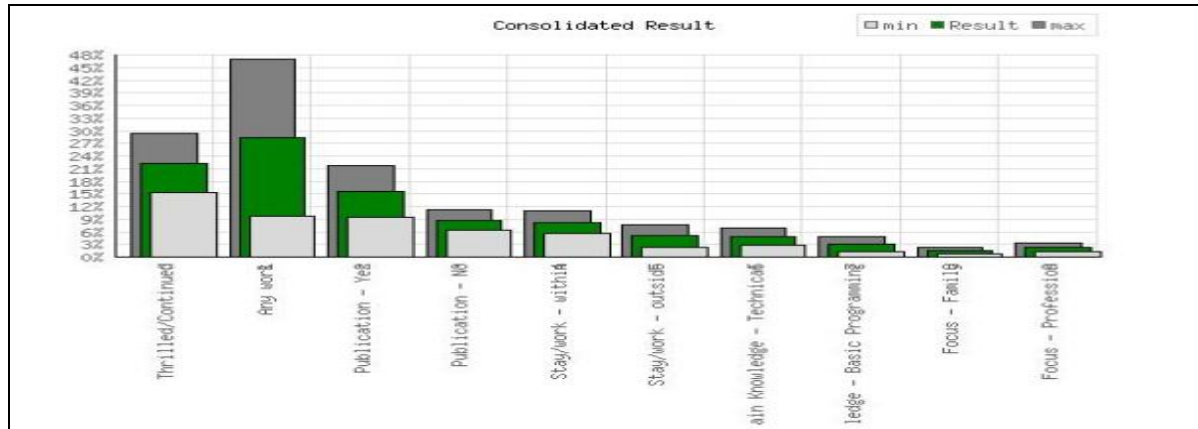
**Fig. 14 Ranking of level 1 – first set of important attributes for selection of PhD students**  
**Conclusion**



**Fig. 15 Ranking of level 1 – second set of important attributes for selection of PhD students**



**Fig. 16 Ranking of level 2 – first set of important attributes for selection of PhD students**  
**Conclusion**



**Fig. 17 Ranking of level 2 – second set of important attributes for selection of PhD students**

**Table 10: Decision formulation for PhD student's selection**

Sr. No.	First Set of Attributes	First Set of Attributes	Second Set of Attributes	Second Set of Attributes
	<b>Level 1</b>	<b>Level 2</b>	<b>Level 1</b>	<b>Level 2</b>
1	Nature of Admission	Full Time	Prior Knowledge	Any work
2		Part Time		Thrilled/continued
3	Profession	Teaching	Publication	Publication - Yes
4		Industry		Publication -No
5	Communication	Good communication	Stay/work	Stay/Work - within
6		Poor communication		Stay/Work - outside

## 5. Conclusion

Someone said that “PhD is the second marriage” and hopefully all individuals on this earth have done, will do a lot of efforts to hunt for the perfect match of their life and efforts to sustain their lifelong unique relationship. Same goes with the ties between the supervisor and the scholar. Both are eager and at the same time kind of unsure about their selection. But the amalgamation of various papers published related to this niche and artistic area will be very useful for all the readers, researchers, guides and scholars too, and hence this study was undertaken. To enhance this work further, we also have carried out the AHP model at multiple stages and suggested the most useful models for all involved entities for this selection. Hope to have wonderful, researchful and peaceful togetherness for both supervisor and scholar here onwards. "Momentum of the candidate who wish to take admission in PhD student is also important to check". Some candidates are so motivated and ready that they come prepared with almost the entire literature

survey before taking admission to PhD program, means they have clear problem statement or they might be working currently on research statements. Such people will become good candidates for the guide. University and guide should check such momentum or motivation in candidates. This model of PhD students selections is by our thinking, lens opted by us based on existing scenarios, you can create your own model based on your perception, thinking etc.

## 6. Future Direction

It is also essential to validate the results with the help of other useful multi-criteria models. In near future we are planning to extend this study including decision tress and TOPSIS, ELECTRE, Linear Assignment and SAW models. We cannot forget the necessity of selection of perfect guide for the scholar. So the other side of the coin will be analyzed in our next paper titled “The art of selecting PhD supervisor”.

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