Experiences and Benefits of Peer Tutoring with Students in Chemistry Subjects

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Abstract: INACAP receives students of different ages and backgrounds, which generates a high diversity in the classroom. The differences in the skills and prior knowledge required for each subject are amplified, discouraging less-advantaged students and impacting their performance, passing, and dropping rates. A systematic work could be positive in the teaching-learning process, especially in complex subjects. This work presents the experience and results with a methodology of peer tutors with a chemistry subject. In each tutoring, the tutors were students with different styles and levels of learning to motivate the complement and feedback of the group work. The students developed autonomy and became aware of their learning process, which positively influenced it. They received academic support to encourage generic competencies such as self-management, teamwork, and problem-solving. The results showed a high student satisfaction rate (84.4%) and a considerable increase in performance in the Mineral Chemistry subject: a 50% increase in the averages and a 25% decrease in failure. The project team is convinced that it is feasible to implement this innovation in other subjects.

Keywords: Teamwork; leadership; methodology for diversity; innovation in higher education; peer tutoring.

1. Introduction

The greater accessibility to Higher Education implies the challenge of having students with a high variability of profiles, both in developing necessary prior skills and personality and character. That requires reception, help, and support programs for students that facilitate their adaptation to the new academic environment (Durán and Vidal, 2004). On the other hand, schools have developed new strategies to enhance student learning considering the individual characteristics of each one and providing community and collaborative solutions (Valdebenito and Durán, 2013).

For this reason, and considering the diversity and heterogeneity of the students who share the classroom, INACAP used equal tutors in Mining Chemistry to share the work of transferring and learning construction among all class participants. This methodology had already been tested at the Higher Education level under different modalities and conditions, with different results. González et al. (2015), in their article on cooperative learning and peer tutoring at the university level in Spain, argue that, at the beginning of the work, students become aware of their personal and technical limitations in the use of available tools and that they react to them, requesting to share a relative weight of the work with the teachers involved in the project. In this sense, students highlight the motivation for innovation and reward since it allows them to choose how, where, when, and with whom to develop a tutoring and learning activity.

In the Latin American context, it is interesting to highlight the conclusions of the peer tutoring experience of Rubio (2009) in Mexico and Torrado-Arenas et al. (2016) in Colombia: The first one highlights that processes that are aimed at self-management of knowledge are activated with results that show that the tutor-peer methodology acts as a mediator, between the new and the old, helping the transit to become a manager of the learning process, while the second highlights the action that students, generally from higher or more advanced semesters, accompany their classmates from previous semesters, in addition to presenting positive experiences in Santander, Colombia.

From a methodological point of view for this work, it was necessary to evaluate and classify students according to their ease with the subject, participate in classes, and learn styles to form the groups correctly and balanced. Once we formed the teams, we worked with problem-solving in a complementary way to the contents of the corresponding unit. In this context, the class material was perfected, and three additional work guides were drawn up to detail the expected learning as much as possible. Subsequently, a feedback process was carried out with the students, with interviews and surveys, to collect their opinions.

Within the work teams of the courses, the teacher chose a leader/tutor who was in charge of leading the workshops within the group. The leader/tutor was chosen by evaluating the students' commitment to the subject, leadership and initiative, and rigor in their work on the subject. Considering the work of the tutor within the work teams, he was responsible for co-evaluating his colleagues about the collaborative work's performance in the classes. The work with tutors was carried out during class hours, and the activities were evaluated using comparison guidelines.

This work organizes as follows: Section 2 describes the main features of peer tutoring as a teaching approach. Section 3 details the academic institution INACAP and the mining study area. Section 4 shows the main results of our study. Section 5 mentions related work. Section 6 concludes this research.

Peer Tutoring

Díaz et al. (2019) highlighted that even though peer learning was apparently perceived as a method for gifted students, today, it is used as an egalitarian and socially inclusive mode. Peer or cooperative learning focuses its gaze on peer interactions to facilitate cognitive issues that provoke a logical resolution of the conflict and achieve cognitive advance (Melero and Fernández, 1995). This type of learning refers to group work in which, above all, positive interdependence is promoted between team members and the need for the contribution of each member to achieve the objective (Durán et al., 2015).

Peer tutoring is a peer learning technique, and it represents a suitable learning method applicable in various areas and contents for the development of social skills and competencies (Moliner et al., 2012). Thanks to the interaction between peers, students learn in an active and participatory way through the help they receive and offer to other peers of similar status. As highlighted by Durán et al. (2015), there are two differentiating roles in each peer tutoring session, the tutor and the tutored. For the student, the learning opportunities of the tutors, since they receive personalized attention and constant help from the tutor, both benefit. The proximity environment of the tutorials generates a climate of trust, which facilitates the tutors to ask questions, outline problems, and make mistakes without fear, attitudes that are very unlikely to develop with the teachers (Duran Y Valdevenito, 2014). Thus, peer tutoring reduces student stress and anxiety with possible academic improvements and greater motivation. In general terms, peer tutoring can generate benefits for both tutors and mentees (Bowman-Perrott et al., 2013; Moliner and Alegre, 2020; Okilwa and Shelby, 2010; Seo and Kim, 2019).

Peer tutoring makes it possible to successfully face the transition to higher education and thus avoid dropping out by bringing students closer to university life with the support of other students (Araneda et al., 2020). According to Castaño et al. (2012), tutors should have developed a priority to communicate effectively, active listening, conflict management, teamwork, and time planning. Besides, teachers have before them a new teaching role because they must face their activity with a different and diverse university student body, which means that they must be able to accompany them in their learning processes and facilitate an integral development that prepares them for life.

The peer tutor model promotes student autonomy, competencies, and comprehensive training from three development perspectives: academic, personal, and professional. All this supposes the student a more active role in their learning process (Blanco et al., 2008). The purpose of peer tutoring is to provide teaching that constitutes a reinforcement or complement for those students who show more significant learning difficulties through so-called conventional systems (Díaz and Morrison, 2016).

The work of Vidal-Bueno (2015) summarizes the benefits of peer tutoring for both the tutor-student and the tutored student and the disadvantages of this teaching-learning methodology (see tables 1 and 2, respectively).

Table 1. Summary of the advantages for student tutor and student tutored of peer tutoring.

Tutor student	Tutored student
Increased involvement, sense of responsibility and self-esteem.	Feel support in decision making and feel that mistakes are shared.
Learning and mastering study techniques.	Acquisition of applicable strategies in other contexts.
Greater control of the content and the task, as well as of the own knowledge.	Higher degree of motivation as a result of commitment to a partner.
Awareness of their own gaps and inaccuracies, as well as the detection and correction of the gaps of the tutored student.	Psychological adjustment thanks to working with an equal. Questions are answered immediately and in a climate of trust.
Improvementofpsychosocialskills.	

3. INACAP Calama and Mining

INACAP is a higher education institution in Chile that is present with 26 branches in the 16 regions of the country. One of its headquarters is located in the mining capital of Chile, Calama, which is close to numerous mining

deposits, a city in which many people work deferred work hours. As reported by Albornoz et al. (2020), INACAP Calama headquarters presents 41% of working students with various previous training, age range, and work experience; that is, a group of students with high heterogeneity in variables of the academic area.

According to entrance studies, INACAP Calama students from the mining and metallurgy area present the following learning styles: active experimentation and reflective observation. Accordingly, these students prefer expository classes to take on the role of impartial observers and learn through specific examples that confront them with practical situations. Then, through the methodology of peer tutors, it would allow these students to develop other skills and change the work methodology in the classroom. By having a high percentage of working students, all the students can incorporate provided and shared experience.

Mining chemistry is a class subject that is dictated for first-year students, during the second semester, in mining and metallurgy. The issue encourages the pedagogical approach of learning by considering methods, techniques, and technological applications of the specialty and promoting commitment, entrepreneurial capacity, and self-management as a hallmark of the INACAP student.

4. Application and Results

The results produced by existing standardized measurement systems in Chile show a high percentage of students who enter higher education without the requirements that will allow them to meet the academic demands in basic science subjects. In other words, an increased number of students do not have a sufficiently solid prior knowledge base to address academic challenges, study habits, various learning strategies, etc. (Díaz and Morrison, 2016). In higher education institutions such as INACAP in Chile, this situation is prevalent, essentially due to the high number of students who carry out work activities and academic ones. According to a survey at the beginning of each course, either a 73% of students did not take chemistry in their previous training or passed it with a poor grade.

Table 2. Summary of the disadvantages of peer tutoring.

For tutors	• Overvaluing themselves, as well as their abilities.
	• Excessofassertiveness
	• Feelingofwasting time.
	• Events that cause a decrease in self-esteem.
In the pairing process	• Feelingofimposition.
	• Rejectionofcertainstudents.
Family perception	• Negativereaction and preference for a traditional education model.

The implementation of peer tutoring was carried out during the spring semesters 2017, 2018, and 2019 in INACAP Calama, of the section and evening, who took the subject of Mining Chemistry. A satisfaction survey and a Kolb learning styles test were carried out, which was analyzed and used to be later able to divide the course into heterogeneous groups and choose a tutor per group and transform diversity in the classroom of these sections into an opportunity for improvement.

From the surveys carried out with the students participating in the project, several conclusions could be drawn. Regarding the students, 62% work, and 73% of the students did not take the chemistry course at school or passed with a regular grade without fully achieving the expected learning in high school. Regarding study habits and motivations, the interviewed students report that at least once a week. Although 55% spend significant time studying and preparing their homework, 45% of them must increase their study hours to obtain better results. Concerning the subject of chemistry, 87% of the surveyed students consider it essential, which is crucial for the motivation and connection that it may have with the professional future. That is why the remaining 13% who do not appreciate the usefulness of the subject must be motivated by carrying out activities so that they can link it

with their professional reality. For 67% of the students who declare that they are encouraged to learn, the group that indicates they have difficulties learning should be empowered and inspired through the tutors.

Table 3. Evaluation of the students of the different contributions of the project.

Material	Average	Standard deviation
Learning guides	6.3	0.7
Flipping classroom	5.5	1.3
Tutors' contribution	5.3	1.9
Teacher contribution	6.4	0.7
The project in general	6.0	1.0

It should be noted that 58% of the students do not know their graduation profile, so they must work together with the director of the area to make this information known to the students. Regarding the contributions of the methodology and the material delivered from the framework of the project, Table 3 details the evaluation of the students on a scale of [1.0 – 7.0].

From table 3, we can infer that the students positively evaluated different dimensions of the project, with the teacher's contribution being the best evaluated and the assistance of the tutors and the inverted class that obtained the lowest grade. That was due to the routine of the traditional educational model and the initial difficulties of implementing the methodology. However, if these grades are taken as a percentage, the project obtained a student satisfaction of 84.4%, which far exceeds the 70% satisfaction self-imposed as a goal.

Regarding the academic results obtained in the project, we evaluated the grade averages, the percentage of failure, and the evolution of grades during the semester. Figure 1 presents the development of the notes from 2013 to 2019, before the pandemic situation.

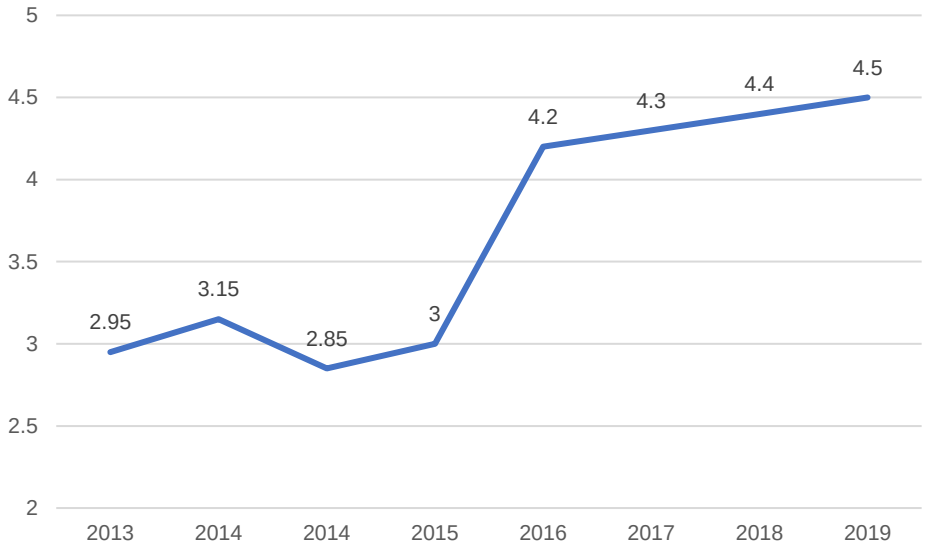

Fig. 1. Average grades in Mining Chemistry from 2013 to 2020.

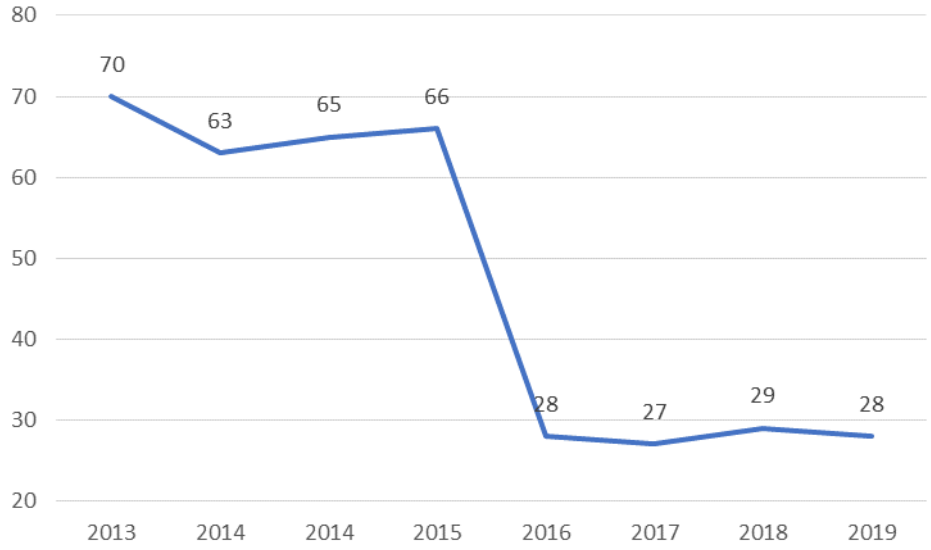

Fig. 2. Failure in mining chemistry as of 2013.

Figure 1 shows the growth of the averages of the subject since the inception of Mining Chemistry increases considerably from 2016, the year in which this work methodology began to be applied. Although the average imposed as an expected result (4.5) was not reached, it was very close. Also, the average for 2015 was exceeded, even though that year there were two additional hours per week for the subject to do assistantships, which did not happen in 2017 where there was still an increase in the average.

Regarding the failure levels, Figure 2 illustrates that the results obtained in the failure levels are in line with the increase in the average and with the progressive and sustained increase between 2016 and 2017 in the subject. On the other hand, we should note that a 35% exemption was obtained in 2017, which exceeds the number of approved in years prior to 2016.

Table 4: Evolution of grades during the spring 2019 semester of Mineral Chemistry.

Assessment	**Average grade**
Assessment 1	4,1
Assessment 2	4,3
Assessment 3	4,9
Assessment 4	5,6

Table 4 shows the ascending characteristic of the grades during the spring 2019 semester of the Mining Chemistry sections. In the first notes, the initial difficulty of establishing the work methodology is appreciated, but they notably improve as they adapt and assimilate the results. This result agrees with González et al. (2015), in the sense that the personal limitations of the students in this methodology must first be known. They are also related to that indicated by Rubio (2009) because the methodology of equal tutors allows activating processes related to self-management and independence.

Related Work

The methodology of teaching-learning peer tutors generates real benefits in the academy, both for the teacher and for the students in their different roles in the areas of knowledge, especially in subjects with high levels of demand that traditionally present high failure rates:

- In the context of primary and secondary education, the work of Nawaz et al. (2017) presents the positive results in the participants' academic performance with a meta-analysis of independent studies of the use of peer tutoring in mathematics courses at different educational stages of childhood and adolescence. The work of Alegre-Ansuategui et al. (2017) describes the positive experience with statistically significant results of peer tutoring with mathematics students from a secondary school in Castellón de la Plana (Spain).

- In a similar context, Alegre et al. (2020) examine the positive effects of peer tutoring on the academic performance of primary and secondary school students in similar settings for the subject of mathematics. In higher education contexts, Zapata (2020) explores the perceptions and benefits of university students in Chile on their peer tutoring experience to align their lack of student competencies with the minimum required to achieve good results. The work of Araneda et al. (2020) describes statistically significant effects of the positive impact of the methodology of peer tutors on the academic performance of first-year university students at a state university in the extreme north of Chile. Likewise, the work of (Wankiiri - Hale et al., 2020) highlights the benefits for student tutors to gain experience that impacts them both academically and personally.

The authors of this work show their experience as tutors during their academic life, which results in a current link in the training of professionals and research in the Chilean academy.

5. Conclusions

According to work presented and the results obtained, we can draw the following main conclusions:

1. Peer tutoring presented a revolutionary teaching-learning methodology for tutors and tutored students; that is, it allows the development of unique competencies to guide their academic and professional future. According to Kolb's typification, students achieve peer interaction according to their diverse learning styles and pace (Blanco, 2017).
2. Students of courses or subjects of high academic demand highly benefit from peer tutoring. Students create an enabling environment that encourages meaningful learning, emphasizing some generic competencies such as teamwork, self-management, and problem-solving.
3. Students develop autonomy, management, and leadership in their search for knowledge, achieving a reflection on their educational work, positively impacting their self-esteem.
4. Teachers are greatly benefited by peer tutoring regarding improvements in student performance, which requires coordination with student tutors to homogenize the objectives and student learning.

References

1. Albornoz-Acosta, J.; Maldonado-Cid, J.; Vidal-Silva, C.; Madariaga, E. (2020).*Impacto y recomendaciones de clase invertida en el proceso de enseñanza-aprendizaje de geometría*, http://dx.doi.org/10.4067/S0718-50062020000300003, Formación Universitaria, 13(3), 3 – 10.
2. Alegre-Ansuategui, F. J.; Moliner-Miravet, L. (2017).*Emotional and cognitive effects of peer tutoring among secondary school mathematics students*, https://doi.org/10.1080/0020739X.2017.1342284, International Journal of mathematical education in science and technology, 48(8), 1185 – 1205.
3. Alegre, F.; Moliner, L.; Maroto, A.; Lorenzo-Valentin, G. (2020).*Academic achievement and peer tutoring in mathematics: a comparison between primary and secondary education*, https://doi.org/10.1177/2158244020929295, SAGE Open, 10(2).
4. Araneda, C.; Obregón, A; Pérez, P. (2020).*Percepción de los estudiantes tutorados sobre el programa de tutores pares y su relación con el desempeño académico: evidencia desde el norte de Chile*, http://dx.doi.org/10.4067/S0718-50062020000300019, Formación Universitaria, 13(3), 19 – 30.
5. Blanco Aliaga, M. R. (2017). *Estilos de aprendizaje y actitudes ante la investigación científica en estudiantes universitarios*, https://doi.org/10.14482/indes.25.2.10960, Investigación y Desarrollo, 25(2), 82 – 99.
6. Bowman-Perrott, Lisa; Davis, Heather; Vannest, Kimberly; Williams, Lauren; Greenwood, Charles; Parker, Richard (2013). *Academic benefits of peer tutoring: A meta-analytic review of single-case research*, http://doi.org/10.1080/02796015.2013.12087490, School Psychology Review, 42(1), 39 – 55.
7. Castaño, E.; Blanco, A.; Asensio, E. (2012).*Competencias para la tutoría: experiencia de formación con profesores universitarios*, https://doi.org/10.4995/redu.2012.6103, Revista de Docencia Universitaria, 10(2), 193 – 210.
8. Diaz, M. M.; Gil, A. B.; Vidal, A. D. (2019).*La tutoría entre iguales: un elemento clave en las aulas interculturales inclusivas*, http://doi.org/10.5209/RCED.57271, Revista complutense de educación, 30(1), 277.
9. Díaz, C. P.; Morrison, R. (2016). *Tutorías en Educación Superior: Posibilidades para la Terapia Ocupacional*, Revista TOG (A Coruña), 13(23).
10. Durán, D.; Valdebenito, V. (2014).*Desarrollo de la competencia lectora a través de la tutoría entre iguales como respuesta a la diversidad del alumnado*, Revista Latinoamericana de Educación Inclusiva, 8(2), 141 – 160.
11. Durán, D.; Flores, M; Valdevenito, V. (2015).*Tutoría entre iguales. Concepto y práctica como metodología para la educación inclusiva*, Revista latinoamericana de Educación Inclusiva, 23 – 40.
12. González, N.; García, R.; Ramírez, A. (2015).*Cooperative learning and peer tutoring in virtual university environments*, http://doi.org/10.4067/S0718-07052015000100007, EstudiosPedagógicos, 42(1), 111 – 124.

13. Melero, M.A.; Fernández, P. (1995).*La interacción social en contextos educativos*, Siglo XXI, Madrid, Spain.
14. Moliner, L.; Moliner, O; Sales, A. (2012).*Porque solos no aprendemos mucho: Una experiencia de tutoría entre iguales recíproca en Educación Primaria*, http://doi.org/10.6018/rie.30.2.145191, Revista de Investigación Educativa, 30(2), 459 – 474.
15. Moliner, L.; Alegre, F. (2020).*Attitudes, beliefs and knowledge of mathematics teachers regarding peer tutoring*, http://doi.org/10.1080/02619768.2020.1803271, European Journal of Teacher Education, 43(4), 1 – 20.
16. Nawaz, A.; Rehman, Z. U. (2017).*Strategy of peer tutoring and students success in mathematics: An analysis*, https://doi.org/10.12973/ejmste/79805, Journal of Research and Reflections in Education, 11(1), 15 – 30.
17. Okilwa, N. S. A.; Shelby, L. (2009).*The effects of peer tutoring on academic performance of students with disabilities in grades 6 through 12: A synthesis of the literature*, http://doi.org/10.1177/0741932509355991, Remedial and Special Education, 31(6), 450 – 463.
18. Rubio, L. (2009). *La tutoría entre pares como apoyo al proceso de aprendizaje de los estudiantes de primer ingreso: ¿aprendizaje mutuo?*, X Congreso Nacional de Investigación Educativa, Veracruz, México.
19. Seo, E. H.; Kim, M. J. (2019).*The effect of peer tutoring for college students: Who benefits more from peer tutoring, tutors or tutees*, http://doi.org/10.15804/tner.19.58.4.07, New Educational Review, 58, 97 – 106.
20. Torrado-Arenas, D. M.; Manríquez-Hernández, E. F.; Ayala-Pimentel, J. O. (2016).*La tutoría entre pares: una estrategia de enseñanza y aprendizaje de histología en la Universidad Industrial de Santander*, http://doi.org/10.18273/revmed.v29n1-2016008, Medicas UIS, 29(1), Bucaramanga, Colombia.
21. Valdebenito, V.; Durán, D. (2013).*La tutoría entre iguales como un potente recurso de aprendizaje entre alumnos: efectos, fluidez y comprensión lectora*, http://doi.org/10.4151/07189729-Vol.52-Iss.1-Art.141, Perspectiva Educacional, 52 (2), 154 – 176.
22. Vidal-Bueno, A. (2015).*Aprendizaje cooperativo: tutoría entre iguales como propuesta de mejora de la comprensión lectora*, Grado de Educación Primaria, Universidad Internacional de la Rioja, Barcelona, Spain,
23. Víllagra-Bravo, C.; Valdebenito-Zambrano, V. (2019).*Tutoría entre iguales como estrategia para la formación del profesorado*, http://doi.org/10.11144/Javeriana.m12-24.tief, Magis, Revista Internacional de Investigación en Educación, 12(24), 161 – 176.
24. Wankiiri-Hale, C.; Maloney, C.; Horvath, Z. (2020).*Assessment of a student peer-tutoring program focusing on the benefits to the tutors*, http://doi.org/10.1002/jdd.12135, Journal of dental education, 84(6), 695 – 703.
25. Zapata, S. (2020). *Perceptions of peer tutoring at a university in Chile*, https://doi.org/10.11144/Javeriana.m12-25.pptu, Magis, RevistaInternacional de InvestigaciónenEducación, 12(25), 21 – 38.
26. Aithal, P. S., and P. M. Suresh Kumar. "Enhancement of Graduate attributes in Higher Education Institutions through Stage Models." IMPACT: International Journal of Research in Business Management (IMPACT: IJRBM) 3.3 (2015): 121-130.
27. JOSEPH, BENNY. "AN EMPIRICAL STUDY ON KNOWLEDGE MANAGEMENT IN HIGHER EDUCATIONAL INSTITUTES: A CASE STUDY OF CHRIST CAMPUS, RAJKOT." International Journal of Humanities and Social Sciences (IJHSS) 6.3 (2017) 111-120
28. Aldeeb, Horiya Mohamed Ahmed, and Adel Mahmoud Al Samman. "MENTORING &LEADERSHIP IN HIGHER EDUCATION: CASE STUDIES FROM BAHRAIN." International Journal of Humanities and Social Sciences (IJHSS) 8.1 (2019) 19-26
29. SAVITHA, S. "IMPORTANCE OF RESERCH ACTIVITIES IN HIGHER EDUCATION." International Journal of Educational Science and Research (IJESR) 6.5 (2016) 27-30
30. CHANDORKAR, NIDHI. "IMPACT OF ORGANISATIONAL CULTURE ON JOB INVOLVEMENT: A STUDY OF HIGHER EDUCATION INSTITUTIONS IN MUMBAI." International Journal of Human Resource Management and Research (IJHRMR) 9.2 (2019) 161-168
31. DWIVEDI, VEDVYAS JAYPRAKASH, and Yogesh C. Joshi. "PRODUCTIVITY IN 21 st CENTURY INDIAN HIGHER EDUCATION INSTITUTIONS." International Journal of Human Resource Management and Research (IJHRMR) 9.4 (2019): 61-80.