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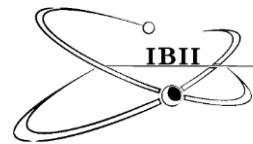
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Marketability of Filipino Teacher Education Graduates

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ABSTRACT

The study investigated the marketability of the Teacher Education graduates of Cebu Normal University. Marketability yields specific skills required not only to gain employment but also attain one's capabilities in the dynamic workplaces. The study surveyed the Graduates of BEEd and BSEd degree programs across personal and professional qualities, special skills and training. It also viewed on marketability values and features on the graduate's employment data or experience adopted from the GTS questionnaires. The study utilized a combination of qualitative and quantitative data collection and analysis techniques. The results affirm that Cebu Normal University; Philippines Education graduates has competed the society that meet the needs of the employer. These pointed out the conclusion that the teacher education graduates are qualified to teach based on their own field of specialization. The study revealed that the graduates are employable based on the specialization. Furthermore, the study concluded that the teachers are qualified and possessed special skills as teachers in the 21st century.

Keywords: Marketability; Filipino teacher education graduates; Employability

1. INTRODUCTION

Dynamic institutions and organizations of the 21st century require skillful and proficient teachers who can think critically, make wise decision, creative, innovative and communicate well in a variety of contexts. UNESCO (2012) reported that modern economy needs highly trained and skilled human resource, and higher education institutions (HEIs) are required to produce qualified graduates to meet the needs of national development and employers.

It is common knowledge that employers prefer graduates that can get jobs done with the best outcome immediately upon hiring. As the number of graduates entering the job market increases,

graduates now need to compete more than ever to get the best or the most suitable job. In the increasingly competitive job market today, universities are constantly challenged to work harder to produce the most employable graduates to suit the needs and demands of today's dynamic workplaces. Many universities worldwide have identified "graduate employability" as one of its key performance indicator to vie for the best students and to remain as the institutions of choice for higher education. Indisputably, graduate employability is therefore, of strategic significance to nation building. Various graduate training schemes launched by the government to alleviate the numbers of jobless graduates. The real test for an educator or teacher and the greatness of universities lies in the employability of its graduates. Employability or 'to have employability skills' means specific skills are required not only to gain employment, but also to progress within an enterprise so as to achieve one's potential and contribute successfully to the enterprise's strategic directions (DEST, 2002).

As a teacher training institution, the primary goal of the Cebu Normal University, College of Teacher Education Programs is to produce good teachers who are qualified to teach in the elementary and secondary schools. Graduates in teacher education program are expected to have acquired teaching and competency skills during their pre-service training to be better prepared for the teaching profession. These skills include: lesson planning, preparation of instructional materials, use of a variety of methods, good communication skills, skills in the use of information technology, problem-solving skills, critical thinking skills, human relations skills and research skills.

For the individual, employability depends on the knowledge, skills, attitudes and values infatuated, the way these assets are used and presented to employers in a milieu. For example, personal circumstances and labor market environment within which the College of Teacher education graduates seek work. The idea for this dimension focuses on graduate employability issues, or rather, the lack of employability in the current local job market. Therefore, there is a need to make a transcribe study of the education graduates not only to trace them but more importantly to discover on how passable is the training provided by the College of Teacher Education in the overall performance of their profession, the employment status of the graduates as well as their achievements in the field.

Education in the 21st century highlights globalization. This implies that patterns of goods and services rendered in the workplace be determined by how much and to what extent do the knowledge, skills and attitudes as well as technology-based competitive advantages required by the global standards are performed effectively and efficiently.

Becker (1993) defines marketability as the individual's ability to obtain and retain a job. In addition, a marketable person is someone who is motivated, self-confident, committed, adaptable, and flexible. He or she is also a team player, and articulate communicator. Brown and Layder, 1996; Lall2000; Lewin 1998 posit that when markets are shifting from the local to global arena, countries that want to survive the global competition of the future are facing tremendous pressures to improve the quality of their work.

The definition used by Peter Husz is as follows: "By human capital we mean the time, experience, knowledge and abilities of an individual household or a generation, which can be used in the production process" (1998). Others only define human capital investment, e.g. Schultz (1992) defines human capital investments as enrolment rates multiplied by the cost of education for one individual. Lucas (1988) measures human capital probably by expenditures on education and "external" human capital, which he believes to be able to measure by calculating the returns to land.

The theory on human capital by Becker suggests that an individual be compensated for the work he or she performs, as well as for the use of that individual's human capital. According to Elman and O'rand (2004) human capital theory and its variants are among the most common explanations of the school-wage relationship. Human capital acquisition is viewed as a lifelong process, although the theory differentiates the components of human capital attainment into those that fall before and those that follow employment. In the same study, they added that educational attainment reflects expected wage remuneration and predicts labor market placement

1.1 Objectives of the Study

The study investigated the determinants towards employability of the Cebu Normal University, Education Graduates for Academic Year 2012, 2013 and 2014. It looked into the graduates' characteristics, employability values and significant attributes of the graduates.

2. SHORT LITERATURE REVIEW

In a study done in University Utara Malaysia, significant predictors for unemployed graduates are ethnicity, English language proficiency, and types of degree obtained. In that study, statistical profiling of unemployed graduates is dominated by Malays, females and with respect to degrees, BBA (Bachelor of Business Administration) form the largest group of unemployed graduates (Lim, 2008).

From the employer's perspective, today's graduates are lacking personality management skills (i.e. positive attitudes, responsibility, adaptability, leadership), exploration skills (i.e. not being imaginative, innovative, critical & creative thinking) and connectivity skills (i.e. communication, IT, team-working, commercial awareness). Hence, academic achievement alone is insufficient for graduates to gain employment (Mohamad and Hamzah, 2009). Furthermore, graduates have a poor command of English, poor character, attitude or personality and asking for unrealistic salary/benefits are a few of the problems faced by employers when hiring fresh graduates.

These findings are important in planning programs to improve the College of Teacher Education Program at the same time give direction on what more can be done to train our education students to meet the demands of teaching. Hillage and Pollard's (1998) widely- cited definition of employability as an individual's ability to gain initial employment, maintain employment, move between roles within the same organization, obtain new employment if required and ideally secure suitable and sufficiently fulfilling work. Mantz Yorke added that "employability refers to a graduate's achievements and his/her potential to obtain a "graduate job", and should not be confused with the actual acquisition of a "graduate job" (which is subject to influences in the environment, a major influence being the state of the economy. There is some evidence suggest that references to employability make the implicit assumption that graduates are young people. The risk is not considering employability in respect of older graduates who have the potential to bring a more extensive life. Employability is not merely an attribute of the new graduate. It needs to be continuously refreshed throughout a person's working life.

The University of Sydney believes that graduates should be more employable, more able to cope with change and more developed as people. The much more recent Dearing Report (NCIHE, 1997) drew particular attention to the vital role that higher education plays in a modern economy. Global competitiveness required that education and training should enable people in an advanced society to compete with the best in the world (NCIHE 1997).

The marketability of a person is also determined by his or her ability to actively involved in co-curriculum activities in school, knowledge in IT, proficient in English, confident and have

planning for the future upon graduation from university (Kabul, et al 2009). It is indicated that leadership skills, communication skills and conflict management skills are some of the employability skills desired by employers (Robinson, 2006). In Woods and King (2002), they stressed that communication skills include oral communication skills, written communication skills, listening skills, face-to-face communication skills and the ability to resolve conflicts positively.

The employability of graduates has become an aim that governments around the world have, to varying extents, imposed on national higher education systems. This interest in employability reflects an acceptance of human capital theory (Becker 1975), under human capital theory, the task of government is to foster conditions that encourage growth in the stock of human capital, since this is seen as vital to performance of knowledge-based economies in a globalized society (Kabul, et al, 2009).

Education and training providers have a statutory duty to evaluate their own activities and participate in external evaluations. Evaluation is used to collect data in support of education policy decisions and as a background for information- and performance-based steering.

Employability has been used as a performance indicator for higher education institutions (Smith et al, 2000) and represents a form of work specific (pro) active adaptability that consists of three dimensions: career identity, personal adaptability and social and human capital (Fugate et al, 2004).

According to Hills, Robertson, Walker, Adey, and Nixon (2003) in de Guzman and Castro (2008) the role of the higher education sector is to supply suitably skilled graduates to the workplace (p. 211). However, de la Harpe, Radloff, and Wyber, in a study conducted in 2000, suggest that there is worldwide concern that existing undergraduate programs are not producing graduates of lifelong learning with the professional skills they need in order to succeed. The issue of employability, as Homes (2001) says, "will be a key quality issue for many years to come".

UNESCO (1980), in a study, observed that in job recruitment, employers' priority may determine the importance of various skills and attitudes for certain job categories. Despite a number of similarities among employers it was observed that either for "promotion" or "hiring" certain criteria have higher ranking in the order of importance, for example, age, sex, religion or beliefs. However, education is very important as recruitment criteria. For educational management positions, professional experience and educational qualifications rank highest. One striking result in the UNESCO (1980) study was the importance of age, when employers are recruiting supervisors and secretaries. But age comes first when recruiting unskilled operators. Employers prefer recruiting managers and supervisors from within the firm because such position often requires job experience (UNESCO, 1980).

3 RESEARCH METHODOLOGY

3.1 Research Design

This study used a combination of qualitative and quantitative data collection and analysis techniques. The qualitative research approaches seek to understand a given research problem or topic from the perspectives of the local population it involves (Cohen et al., 2009). According to Fellows and Liu (2006) a qualitative research, an exploration of the subject is undertaken without prior formulations in the object to gain understanding and collect information and data such that theories will emerge. In quantitative design approach, it is focused on the collection and analysis

of numerical data and statistics hence a scientific method (Molwane, 2002 and Fellows and Liu, 2006).

The data will be collected thru mails, interviews and personal delivery. The addresses of the respondents were taken from their school records at the registrar's office and from the list provided by some respondents.

3.2 Research Environment

The present Cebu Normal University was formerly Cebu Normal School then Cebu State College which started as Secondary School in 1915. Last June 27, 1998 Cebu State College was converted to Cebu Normal University by virtue of RA 8688. The institution's prestige as a premier training for teachers has been sustained through the years. Today CNU has offered plenty of courses like Nursing, Liberal Arts and Graduate Studies. However, its flagship has long been the education. It has provided the city and the neighboring provinces with efficient and effective teachers.

This institution has fourfold function of institution, research, extension and production. Its main thrust is to provide higher professional and special instruction that aims for quality education, professional leadership training anchored in relevant, responsive and functional curricula with the vision of producing graduates who are not just knowledgeable and skillful but value-oriented citizens as well.

3.3 Research Respondents

As presented in the list from the registrar's office, the total number of education graduates for Academic Year 2012-2013 is 1,189. These Education graduates of batch 2012 and 2013 hail from the different cities and municipalities in the province of Cebu and other neighboring provinces.

3.4 Research Instrument

The instrument to be used in this study is survey questionnaires adopted from the CHED GTS questionnaires. This is made of open-ended and checklist type of questions. This consists of the general information about the graduate, educational attainment, marketability values and features and the last part consists of items on the graduate's employment data or experience after college.

3.5 Data Collection Procedure

The names of possible respondents will be taken from the list provided by the registrar. The researchers will collect the data through mails and focus group discussion. For those within Cebu City the researchers will personally distribute and retrieve the questionnaires. For those outside Cebu City, the researcher may request some students coming from the same municipality to distribute and retrieve the questionnaires. Personal interview will also be conducted to validate the data gathered.

4 RESULTS AND DISCUSSION

Table 1: Number of Graduates A. Y. 2011-2012, 2012-2013 & 2013-2014

BEED Gen Ed	142	135	95.1%	101	86	85.15%	118	115	97.45 %
BEED ECE	94	90	95.7%	58	50	86.2%	56	54	96.4%
BEED SPED	87	82	94.3%	62	55	88.7%	83	82	98.8%
BSED Math	78	76	97.4%	56	51	91.1%	69	64	92.7%
BSED English	86	82	95.3%	70	62	88.6%	87	85	97.7%
BSED Filipino	24	22	91.7%	14	13	92.9%	32	31	96.8%
BSED Soc. Studies	12	11	91.7%	9	7	77.8%	19	17	89.47 %
BSED Physical Science	16	16	100%	12	11	91.7%	12	11	91.6%
BSED Biological Science	20	19	95%	18	16	88.9%	25	22	88%
BSED MAPEH	20	15	75%	25	20	80%	27	24	88.88 %
BSED TLE	5	5	100%	5	5	100%	10	8	8%
TOTAL	584	553	94.7%	430	376	87.4%	538	513	95.35 %

To gather in-depth information on employability of the CNU-CTE graduates, e-groups was retrieved and the researchers communicated the respondents personally and via facebook (Boholano, 2012). In the teaching arena, the percentage of Bachelor of Elementary Education (BEED) and Bachelor of Secondary Education (BSED) who graduated last March 2012 have greater job opportunity compared to those who graduated a year after. All BSED Physical Science and TLE graduates are marketable of the 2012. This shows that goods and services they have rendered in the workplace are firm by how much and to what extent do their knowledge, skills, attitudes and values required by the overall standards, since most number of batch 2012 graduates are in the workstation.

The time, practice, knowledge and abilities of the 2013 generation, which can be used in the association process has lower percentage marks because of the components in the human capital completion into those that fall before the year. This affirms that CNU Education graduates has competed the society since they were already hired for employment. According to Brennan et. al.

Table 2: Number of Graduates Employed either teaching or non-teaching

Degree Program & Specialization	2012					2013					2014				
	No. of Graduates Employed	Teaching	%	Non-teaching	%	No. of Graduate Employees Employed	Teaching	%	Non-teaching	%	No. of Graduates Employed	Teaching	%	Non-teaching	%
BEED Gen Ed	135	120	88.9%	15	11.1%	86	75	87.2%	11	12.8%	115	113	98.26%	2	1.74%
BEED ECE	90	79	87.8%	11	12.2%	50	45	90%	5	10%	54	51	94.4%	3	5.56%
BEED SPED	82	69	84.1%	13	15.9%	51	44	86.3%	7	13.7%	82	81	98.78%	1	1.21%
BSED Math	76	68	89.5%	8	10.5%	47	40	85.1%	7	14.9%	64	63	98.44%	1	1.56%
BSED English	82	71	86.6%	11	13.4%	52	48	92.3%	4	14.7%	85	82	96.47%	3	3.66%
BSED Filipino	22	16	72.7%	6	27.3%	10	8	80%	2	7.7%	31	31	100%	0	0
BSED Soc. Studies	11	9	81.8%	2	18.2%	4	4	100%	0	20%	17	17	100%	0	0
BSED Physical Science	16	14	87.5%	2	12.5%	8	7	87.5%	1	0%	11	10	90.9%	1	9.1%
BSED Biological Science	19	17	89.5%	2	10.5%	11	10	90.9%	1	12.5%	22	20	90.9%	2	9.1%
BSED MAPEH	15	13	86.7%	2	13.3%	15	12	80%	3	9.1%	24	21	87.5%	3	1.25%
BSED TLE	5	5	100%	0	0	4	4	100%	0	20%	8	8	100%	0	0

(2003) as cited in Boholano (2012), the employability of English graduates is rather poor light; at six months after graduation over half of English graduates were in full-time paid employment but this was below the proportions for all English major graduates.

As shown in the table only BSED TLE AND Social Studies major graduates are all employed as teachers. Not only because they are very few but this proves that graduates in this subject area are in demand. Skills learned from this area are also needed in preparing these high school students, their future learners to be prepared in vocational and technical skills which can lead them for employment even if they could not yet finish a baccalaureate degree. The second in rank in 2014 is the English majors. This could also be related to their jobs as tutors because they are not yet legally employed as professional teachers. Many of these English majors now are tutoring foreign students like Koreans, Japanese and even Germans who are residing in the city. Some just simply continued to be tutors because they have been doing it since they were still students. This is one of their part time jobs. This is related to this idea based on an analysis conducted between June to December 2006' It was found that the most highly valued generic skills are oral and written communication skills, interpersonal skills, ability to work in a team, problem solving and decision making skills, leadership and computer literacy (Ranjit Singh Malhi 2008). Written and oral communication skills and critical thinking are just some of the strengths mentioned by English graduates themselves which will qualify them to be employed in private sectors (Boholano, 2012).

Furthermore, the analysis found that the key traits employers are keen to look for are on the achievement orientation such as self-motivation, proactive, high integrity, reliable, able to work independently with minimal supervision, emotionally stable and able to perform well under pressure.

The BSED Biological Sciences is the third in the rank because many teachers in the elementary are needed both in private and public schools. Most of these young graduates now are teaching in private schools because they are accepted even if they are not yet board Passers. However, majority of these graduates were really employed as teachers. Only in 2013, where BSED Social Studies and Filipino graduates more were employed not in teaching but were in the call centers. This is the employment where what they have learned from the university like communication skills can easily be applied. Some of our MAPEH majors are occupied in being choreographers and party organizers so they did not yet seek employment in teaching.

The main reason why not all are teaching is that teaching plantilla is not commensurate to the number of graduates. Comparing school years 2012-2013, it is very evident that in the previous year many are already working and mostly are hired as teachers already. This is the effect of having one year already after graduation. Some of them had rested after being students, after a year they already decided to start working. Many said they are already ashamed from their parents to always ask money so they started to. The clear cut issue in this case is that many of the local institutions of higher learning; both public and private like Cebu Normal University have not failed to offer a sufficiently rigorous education to produce the necessary quality in the workforce which the industry requires." Wetch (1970) as cited in Boholano (2012) argues that education and skill possession produce two effects-----more pay and more productivity. In the same study, it is found out that basic skill, attitude and behaviors were very important to be employed, while competence was seriously considered in the supplementary education industry

Table 3: Reasons Provided by the Teachers for Wanting to Change Current Job

The Table presents certain reasons why teachers want to change their teaching career. As gleaned from the data, twenty percent (20%) of the teacher –respondents admit that oftentimes teacher salaries are not released on time hence they are prompted to borrow a certain amount of money from the loan sharks with a sizeable amount of interest rate. Married ones expressed that sometimes they experience sending promissory notes to the schools of their children for the permission to take either Mid- term or Final examinations. Likewise, for the single ones, aside from giving financial support to their parents, they too, help in their siblings' even their immediate relatives' education. Further during the interview, majority noted that had the salary be given on time they could have stayed put as teachers because teaching is what they have been trained for but for practical reasons, they leave and land another job with the assurance that they go back to teaching once they become financially stable.

Another reason why these teachers want to change their current job as teachers is their limited opportunity for promotion with nineteen percent (19%) data on record. Conscious of the scenario that teacher promotion especially in the Department of Education is somewhat hierarchical, thus longer time is still needed to climb up the ladder. A few even noted although based only on observation, that ranking of teachers is done subjectively. On the positive note however, some admit that before they get promoted they need to enroll themselves in further studies. This somehow made them feel that "going up" takes a longer time considering that almost always teachers retire first from the teaching job at the age of 65 before position becomes vacant. Thereafter competition becomes stiff.

Seventeen percent (17%) of the respondents also shared that another reason why they left the teaching career is the security of tenure. They believe that while they are in the teaching service they feel uncertain of their future. According to them, since they are still young, chances are qualifications become stringent thus priority is given to those teachers who have advanced experience in teaching.

Having low motivation with fifteen percent (15%) respondents agreeing, stated that they lack the inspiration and encouragement to go further teaching hence they transferred to another career. They further noted that primarily, teaching is their parents' choice. Secondly as observed, oftentimes newcomers to the teaching job are assigned to teach in far-flung areas where they feel

“away from civilization.” They added that with their desire to teach in central schools, they just couldn’t because of the so-called hierarchical process. Apart from these, they see that most of our schools now are wanting in instructional materials, added to 60-70 students in a class and not to mention varied behaviors of students coming from the different family backgrounds. These scenarios obviously stunt their motivation to teach.

Down the line is fourteen percent (14%) of the respondents articulated that since professional training is seldom offered to them, they are carried away to go out of teaching and look for another job. As observed, the same teachers are oftentimes given the chance to attend relevant trainings and seminars. Somehow they are disoriented since in the undergraduate studies, they learn that to further develop their teaching competence teachers especially the new ones are the first priority to such. What happens is if there are seminars open for teachers, they personally attend but pay for the registration themselves. Aside from that, they are absent from their classes. Things like these made them realize that professional upliftment entails a long process as well.

One reason which the respondents rated the lowest percentage of thirteen percent (13%) in terms of reasons of transferring is that environment is not friendly. Obviously classes both in elementary and secondary are generally crowded most especially in the public schools. Coupled to that is the large number of students per class. Thus they declared that since this issue is immemorial it is remote that things would improve that soon. Being in this situation hampers their enthusiasm because understandably improvement in this aspect is based on the national decision among policy makers.

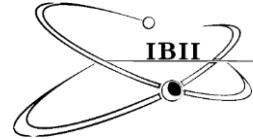
5 CONCLUSION

The study presented the percentage of employment of the teacher education graduates of Cebu Normal University. Based on the findings of the study, the graduates are employable in different schools either public or private. The teacher education graduates and qualified to teach based in their own field of specialization. Graduates from a normal school who is Center of Excellence in Education is better the other graduates. Thus, it is very evident that the graduates in Cebu Normal University are employable in school and other agencies.

REFERENCES

- [1] Becker, G. (1993). *"Human Capital, A Theoretical and Empirical Analysis with Special Reference to Education"*, National Bureau of Economic Research, The University of Chicago Press, Chicago.
- [2] Boholano, H. (2012). Employability of Teacher Education Graduates of an Asian Public University. doi: <http://dx.doi.org/10.7719/jpair.v9i1.12>
- [3] DEST, 2002. Employability Skills for the Future. A report by the Australian Chamber of Commerce and Industry and the Business Council for Australia for the Department of Education, Science and Training, Canberra
- [4] Hills, J. M., Robertson, G., Walker, R., Adey, M. A., & Nixon, I. 2003. Bridging the gap between degree programme curricula and employability through implementation of work-related learning. *Teaching in Higher Education*, 8(2), 211-231.

- [5] Kabul, W. Henry, B. and Hansaram, R. (2009). Employability and Marketability: Employers and Graduates perception in Sabah, Malaysia.
- [6] Lim, H. (2008). Predicting low employability graduates: The case of Universiti Utara Malaysia. *The Singapore Economic Review*
- [7] Husz, M (1998). "*Human Capital, Endogenous Growth, and Government Policy*", Peter Lang GmbH, Frankfurt am Main.
- [8] Mohamad, H., & Hamzah, M.S.G. (2009) Employability of profiles of graduates: The Malaysian scenario from an employer perspective. The 5th QS-Apple Conference, Kuala Lumpur
- [9] Lucas, R. (1998). "*On the Mechanic of Economic Development*" in: "Journal of Monetary Economics", 22 (1988), pp. 3-42.
- [10] Schonewille, Mark (2001). "*Does Training Make a Difference? Institutional Environment and Returns to Human Capital*", paper for the International Labour Market conference at Aberdeen, University of Nijmegen.
- [11] Schultz, Paul (1992). "*The Role of Education and Human Capital in Economic Development: An Empirical Assessment*", paper presented at the conference on Economic Growth in the World Economy, Institut für Weltwirtschaft, Kiel, 1992.
- [12] Wood, H. R., and King, J. Z. (2002). *Leadership and management in the hospitality industry.* (2nd ed.). Educational Institute, American Hotel and Lodging Association.
- [13] Human capital defined <http://home.wanadoo.nl/mark.sch/ec/hcdef.html>



Big Data Has Unique Needs for Information Governance and Data Quality

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ABSTRACT

Enterprises that are venturing into the technical environment of big data and are attempting to create a data lake environment need to take precautions. The principles of information governance and data quality need to be applied to the new world of big data to avoid the trap of the data lake turning into a data swamp. Applying the seven V's of big data as foundational principles for information governance and data quality will help ensure the long-term success of the expertise big data environment.

Keywords: Big data; Data lake, Seven V's; Information governance; Data quality

1. INTRODUCTION

Data is growing at an astonishing rate. As individuals, small organizations, and all the way to global enterprises generate, use, and store data. The types and sources of data continue to expand and convert to digital media. From wearables to appliances to industrial equipment are becoming sensor enabled, all of these devices are fueling the growth of data. Increasingly business transactions, social interactions, and entertainment are becoming digitally driven. The mountain of data will either be turned into usable information or lose its value and turn into dark data. As enterprises embark on their big data adventure, there is a desire to capture and retain the value inherited with insights. Data lakes are a method for economically storing massive amounts of data but in order for the data to be useful as information, thereby an asset, the integrity of the data must be maintained and a means to retrieve the data out of the data lake needs to be planned before investing time and effort to populate the data lake.

2. BIG DATA ENVIRONMENT

There has been established industry leading practices and standards for the care and feeding of enterprise data for an extended period of time. Data Management Association (DAMA) created a framework guide in 2009 called Data Management Body of Knowledge (DMBOK). This frame work has data governance as the center of activity and the central knowledge domain that connects all the other domains.



Fig. 1 DAMA DMBOK Guide Knowledge Area Wheel

DMBOK gave appropriate guidance from simple to highly complex environments. But now, the volume, types, and speed of data are challenging how data professionals address the needs to maintain the integrity of data in the new big data era. Yet the underlining principles remain consistent.



Fig. 2 Image of stylized Data Lake

economic way. The incoming flows of data into the data lake can have a variety of formats. Structured data is information that can be store in rows and columns. This is the traditional data format that existing infrastructure and tools have been developed over time. Unstructured data is typically under-organized and does not fit well in the more traditional tools. Unstructured data

- Data Architecture Management
- Data Development
- Data Operations Management
- Data Security Management
- Data Integration and Interoperability
- Document and Content Management
- Reference and Master Data
- Data Warehousing and Business Intelligence
- Metadata Management
- Data Quality Management

From the perspective of an enterprise with a more traditional business model and use of structured data, frameworks such as DAMA

In the new big data era, there are a variety of technologies and vendors that foster the creating, using, and storing of data in a wide variety of formats. The structure around these repositories are referred to as Modern Data Architecture (MDA) and the large data stores are known as Data Lakes. Their primary function is to store large amounts of data in a financially

can exist in multiple general formats such as e-mails, PDF documents, sensor feeds, images, audio, and video as well as other general formats.

One of the issues that have plagued Information Technology (IT) and data management professions as well as the end consumer of data alike is that there is a Pareto relationship of around 80% of the time and effort is spent on preparing the data to be usable and around 20% of the time and effort is spent actually using the data. Therefore, there are opportunities to apply principles to improve the effectiveness and efficiencies of data storage and retrieval.

3 SEVEN FOUNDATIONAL PRINCIPLES OF BIG DATA

The three “V” words commonly used to describe Big Data – volume, velocity, and variety – define the proportional dimensions and challenges specific to big data but fail to fully describe the whole concept of Big Data. The other “V”’s are aspirational qualities of all data and provide a more complete picture to describe the attributed of big data and what is necessary to maintain the integrity of the data as well as be able to leverage data as a value generating asset are summarized in the seven foundation V’s of big data.



Fig. 3 Seven V's of Big Data

- Volume
- Velocity
- Variety
- Veracity
- Virtual
- Variability
- Value

Companies are increasingly turning to Big Data as a means of better using structured and unstructured data generated by operations not only to enhance safety, efficiency and productivity, but to predict events before they happen.

Having a data quality issue is much more than just an inconvenience, missing or misleading data can be very expensive and can even cost lives. “Poor data can cost businesses 20%–35% of their operating revenue”, Chad Luckie May 2012.

Many of these principles complement each other and it is common for data to experience two or more of these principles at the same time and as data goes through its life cycle, the principles describing the data may change as well as the governing needs of the data.

3.1 Volume

Volume is the scale of data. While big data is not all about the size of data, the growth in the volume in data is impressive. According to International Data Corporation (IDC) estimates, by 2020, business transactions on the internet business-to-business and business-to-consumer

will reach 450 billion per day. And according to IBM on their big data blog, over 90% of all the data in the world has been created in the past two years. The size of data used to be measured in megabytes, now data is being measured in terms of exabytes (1,000,000,000,000,000 bytes) and zettabytes (1,000,000,000,000,000,000 bytes). The Industrial Internet of

Things (IIoT) is a source of sensor data. Dylan Twenty reports that jet engines from GE generate 500 gigabytes of data during every flight. This data is stored for analysis of the health of the engines. Sensor and device data feeds are the major contributor of digital data growth yet social media, Voice over Internet Protocol (VoIP), and enterprise data are all contributing to the

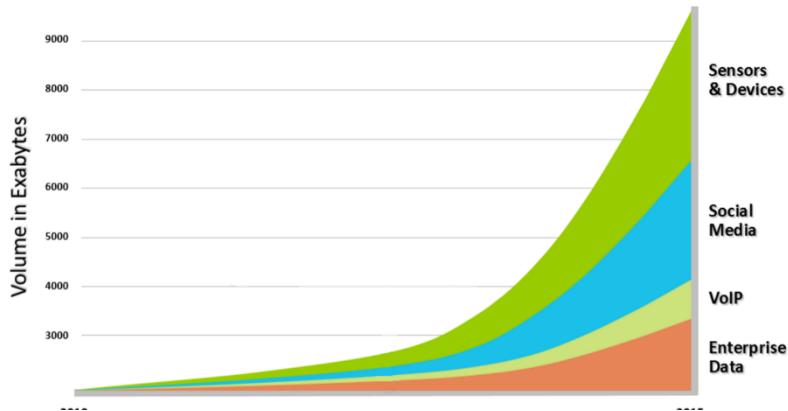


Fig. 4: Volume - digital data growth chart - Di Como

massive growth of digital data. If data is not properly sorted and tagged, then the usefulness and value of the data is dramatically reduced.

3.2 Velocity

Velocity is the rate of change that the data experiences. The velocity of data is described as data at rest, data in use, and data in motion. Data at rest is typically associated with master data, archived data and other data sources that are static. Data at rest is data that is not changing. Data in use is typically associated with transactional data.

An example of transactional data would be the interconnected processes of a sales order. The financial transaction that occurs with the financial institution, inventory updates and the corresponding inventory checking in the warehouse and material requirements planning (MRP), and the delivery process. Data in motion is the movement of data from one application to another application. An example of data in motion could be back-up and archiving, retrieving data from one application to another in order to complete a transaction, or sensor data flowing to the primary repository for processing. Depending on the use case, some data in motion can be

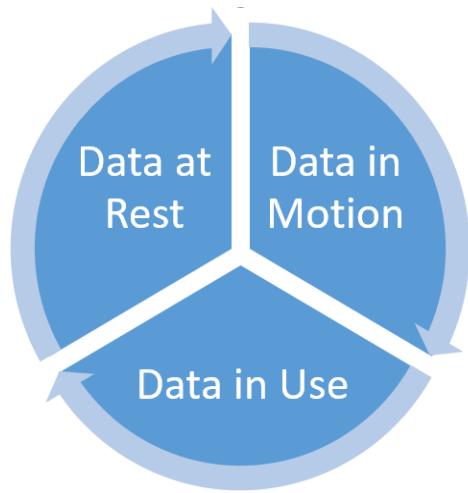


Fig. 5 Velocity

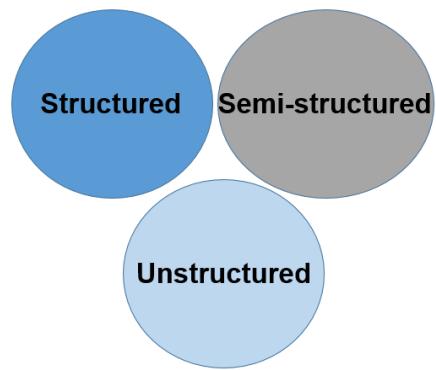
processed near the source, thus diminishing the need to move the majority of the data. This is referred to as data on the edge. Each type of velocity has its own governance requirements.

3.3 Variety

Variety is various forms that data can take. It is common to think of data variety as structured data, unstructured data, and semi-structured data. Structured data is the more traditional

Fig. 6 Variety

enterprise data that fits into rows and columns. Structured data is easily stored in databases and there is a wide array of tools available to retrieve date from the databases. Unstructured data is data that does not fit neatly into rows and columns. Unstructured data can exist in multiple general formats such as e-mails, PDF documents, sensor feeds, images, audio, and video as well as other general formats. Unstructured data is more difficult to classify and the current commercial tools to retrieve unstructured data are still early in their maturity lifecycle. Semi-structured data is unstructured data that has identifying tags called metadata to help identify the data for later retrieval. "Metadata summarize basic information about data which can make finding and working with particular instances of data easier." Keith Holdaway 2014.



3.4 Veracity

Veracity is correctness or accuracy of the data along with the context of the data that leads to trust. Three aspects of veracity are data lineage, traceability, and integrity. Data lineage is knowing the source of the data. If the data comes from a trusted source such as the enterprise accounting system that has controls built into it, then the data itself is more trusted. Traceability is the ability to accurately trace where the data came from. If the report is generated out of the corporate data lake but the individual data elements have their source from a trusted system and can be shown that the data elements have not been modified, then the trust of the source system is inherited. On the other hand, if the source of data is coming from an individual's spreadsheet that were updated on their workstation, then a compelling argument can be made that the data should not be trusted.

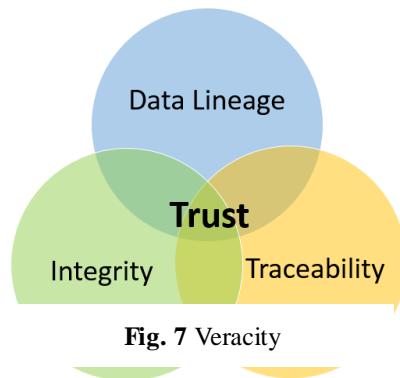


Fig. 7 Veracity

3.5 Virtual

Virtualization is extending the applications and their respective data sources to an abstraction layer so the data from disparate systems appears as a unified table. There are five patterns of data virtualization use. Data federation, data warehouse extension, enterprise data sharing, real-time enterprise data, and cloud data integration. Data federation is used when there are multiple and comparable source applications. Data federation is useful for creating federated views, data services, data mash-ups, caches, virtual data marts, and virtual operational stores. Data warehouse extension are useful for Master Data Management (MDM) hub extensions, data warehouse federation, hub and virtual spoke, complementing Extract Transform Load (ETL) interfaces, data warehouse prototyping, and data warehouse migrations. Enterprise data sharing is useful for shared data services, creating a data abstraction layer, standard-compliance data services, and data virtualization competency center. Real-time enterprise data is for the fast paced enterprise that needs real-time access to their data. Cloud data integration for access and delivery of data to the cloud.

Before virtualizations, traditional techniques were to move the date from disparate systems to the application for processing. There are now tools and techniques maturing in the marketplace to allow a compostable landscape, where logic is brought to the data.

3.6 Variability

Variability refers to data whose meaning is constantly changing. Words do not have static definitions, and their meaning can vary wildly in context. Individual words without context can be very misleading. Same can be true for a numeric stream. Data flows can be highly inconsistent with periodic peaks and valleys. For example, is the variance due to seasonal trends or is there a true anomaly indicating a problem? When the data set is divergent from the average or mean or in other words, the data is outside the range of normal taken in context of the previous V's. The four measures of variability that are commonly used are range, mean, variance and standard deviation. These variability measurements can occur in any of the previous V's and can be depended on their stage in the data lifecycle. Establishing variability standards allows for using tools to monitor the data and manage the exceptions when they occur. Historical context can be used to generate regression analysis for insights on correlations or Principle Components Analysis (PCA) to help avoid the trap of making decisions on spurious relationships, and Monte Carlo simulations can lead to great insights and predictions.

3.7 Value

Value is the accumulation of applying both tactical and strategic governance to big data in the previous 6 “V’s” Enterprises commonly treat data as a cost but should treat data as one of the most valuable asset of the enterprise. Trusted information can be used for descriptive, predictive, and prescriptive analytics. Descriptive analytic is reporting on data generated events that occurred in the past. Dashboards are a common use of descriptive analytic. Predictive analytic uses data generating events that had occurred and makes a prediction on what is going to occur next. Analytics such as regression analysis are used for prediction. It is important to note that a co-variance in variables that show relationships does not imply causation. Prescriptive analytics is the next step from predictive analytic. Prescriptive analytics uses data generating events that had occurred and makes a prediction on what is going to occur next and provide an advice on how to react to the prediction. Correct, complete, and trusted data will enhance people, process, and technology.

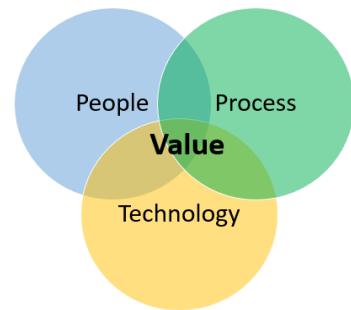


Fig.8 Value

4 INPUT PROCESSING OUTPUT

Every process regardless if it is automated or manual, an over-arching macro process or low-level details micro process, all contain the basic components of Input, Process, Output. And if it is governed, then it has controls and mechanism. In the context of computer systems,

inputs are the data feeds that go into the computer program. The inputs can be as simple as a person typing on the keyboard or as complex as sensor data off of a jet engine. The higher the quality of the inputs the better. Processing is the computer program that takes the inputs and applies logic to the data and makes some kind of decision. Outputs are the results of the logic and the decisions that were made. If there is information governance in place, then the controls are the rules and standards. Mechanisms are the way to apply and enforce the controls. If the process is more sophisticated, then there can be a feedback loop for continuous learning.

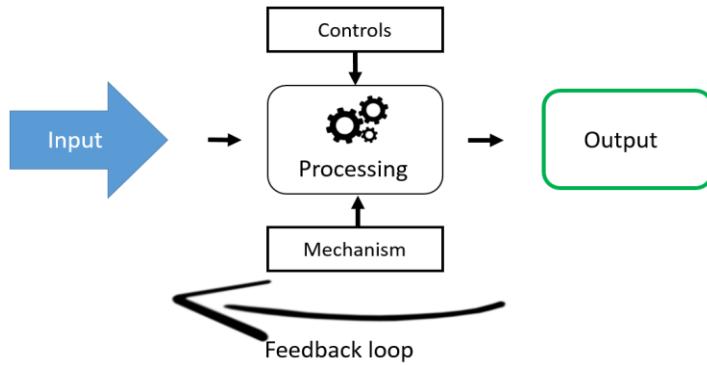


Fig.9 Input Process Output

5 METAPHOR FOR DATA QUALITY

The following metaphor is to illustrate that making decision with partial information without considering the bigger picture can lead to inaccurate conclusions.

5.1 Anscombe's Quartet

The following table contains 11 observations from four different datasets. Each dataset is statistically very similar. When statistical analysis is applied, the common measures of R^2 , Means, and P values are identical for the four data sets up to three significant digits, strongly indicating that these data sets represent the same values.

	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4
1	10	8.04	10	9.14	10	7.46	8	6.58
2	8	6.95	8	8.14	8	6.77	8	5.76
3	13	7.58	13	8.74	13	12.74	8	7.71
4	9	8.81	9	8.77	9	7.11	8	8.84
5	11	8.33	11	9.26	11	7.81	8	8.47
6	14	9.96	14	8.1	14	8.84	8	7.04
7	6	7.24	6	6.13	6	6.08	8	5.25
8	4	4.26	4	3.1	4	5.39	19	12.5
9	12	10.84	12	9.13	12	8.15	8	5.56
10	7	4.82	7	7.26	7	6.42	8	7.91
11	5	5.68	5	4.74	5	5.73	8	6.89

Table 1. Anscombe's Quartet

But with further investigation and visualizing the data, it become obvious that these four data sets are distinctive and unique after all.

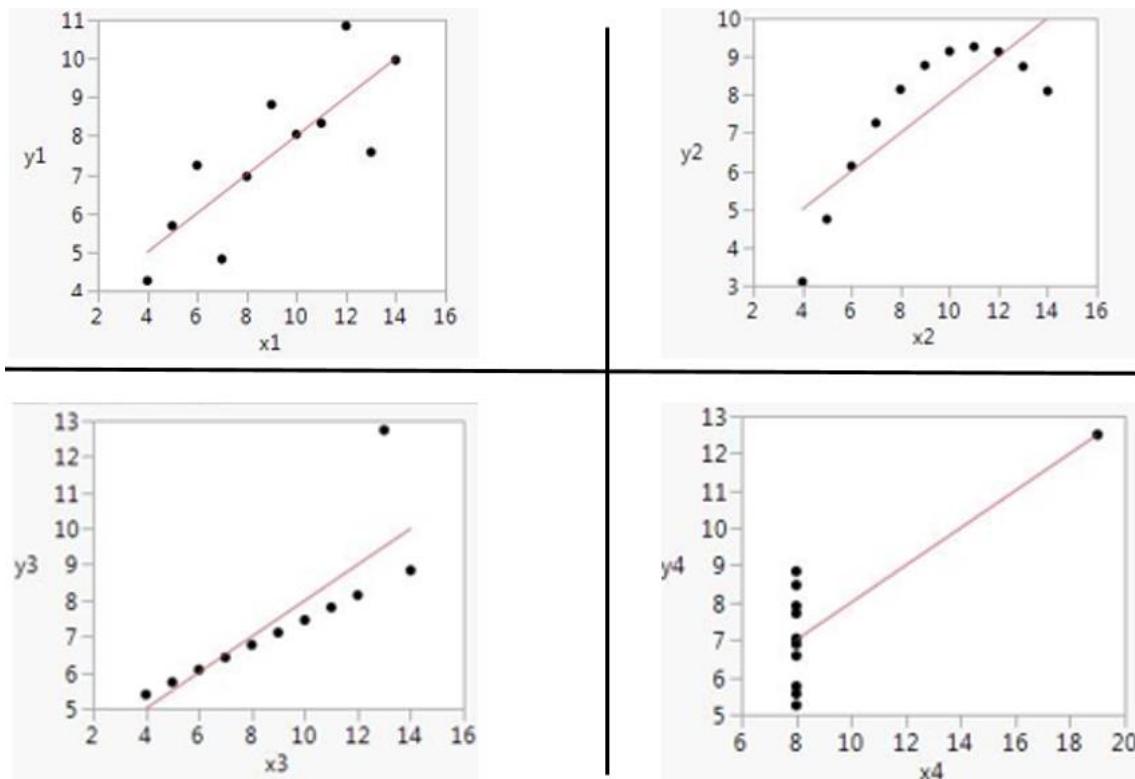


Fig. 10 Results of Anscombe's Quartet (Scatter Plot from SAS)

Illustrating the point that ungoverned and incomplete data can lead to inaccurate conclusions.

6 CONCLUSION

Enterprises that leverage and use the data they currently have access to as valuable information used for descriptive, predictive, and prescriptive analytics and treating data as a value generating asset that complements people, process, and technology will have a competitive advantage. The big data era is upon us and the established trend is that the volume of data will continue to grow at an astonishing rate. The fundamental concepts and processes for managing and governing data with the goal of maintaining data integrity and usefulness have not changed but the application and details of information governance are going through a significant metamorphosis. Big data introduces challenges that go beyond the proportional properties of volume, velocity, and variety. Information governance also requires management of veracity, virtual, variability, and value. At any point in time during the lifecycle of data, two or more of these seven properties can unite and create unique sets of circumstances and requirements. Information governance and data quality professionals are having to be flexible and adaptive to this new landscape of big data.

It is the suggestion of this author that next steps in the study of information governance in the big data era would be to create an instrument for capturing information governance maturity and effectiveness and conduct an experiment with a convenience sample of mid-sized to large enterprises. The experiment would by necessity have to be quasi experimental due to missing control group.

E(R) O1 X O2 where E(R) is Experiment Result, O1 is first observation, X is the manipulation, O2 is second observation.

Observation 1, conduct survey on information governance maturity and perceived effectiveness of information governance on big data to create a base line observation.

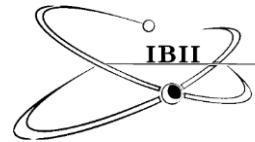
Manipulation, implement big data information governance in the enterprises.

Observation 2, conduct survey on information governance maturity and perceived effectiveness of information governance on big data after implementing information governance to measure if maturing and perceived effectiveness changed.

In an effort to avoid Type II Errors, the hypothesis should include implementing information governance would not have a significant effect ($P > .05$) on maturity and perceived effectiveness of information governance. The null hypothesis should include that implementing information governance would have a significant effect ($P < .05$) on maturity and perceived effectiveness of information governance.

REFERENCES

- [1] Mosley M., Et al..., The data management body of knowledge, DAMA-DMBOK Guide (Technics), USA, 2009.
- [2] Luckie C., <http://www.fathomdelivers.com/blog/analytics-and-big-data/big-data-facts-and-statistics-that-will-shock-you/>, May 8, 2012
- [3] IDC, <http://wikibon.org/blog/unstructured-data>
- [4] IBM, <http://www-01.ibm.com/software/data/bigdata/what-is-big-data.html>
- [5] Tweney D., <http://venturebeat.com/2015/06/18/heres-coming-the-industrial-internet-and-enormous-amounts-of-data/>
- [6] Di Como P., Review of performance evaluation benchmarks of apache Hadoop, https://www.politesi.polimi.it/bitstream/10589/93418/1/PUSTINA_749598_ReviewOfPerformanceEvaluationBenchmarksHadoop.pdf, 2014
- [7] Holdaway K., Harness oil and gas big data with analytics (Wiley), USA, p.310, 2014
- [8] Kitchin R., The Data Revolution: Big Data, Open Data, Data Infrastructures and their consequences (Sage), USA, 2014



Servant Leadership as A Leadership Model

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ABSTRACT

Research and popular writing on the subject of leadership continues at a rapid pace. The leadership section at local bookstores and libraries gives evidence to the growing number of volumes written from numerous perspectives and from a wide range of experience. There appears to be no quarrel with the idea that leadership is in short supply, yet it is vitally important to every type of organization. Within this mass of literature are those who explore various theories, approaches, and styles, as well as those who offer their own brand of leadership principles that are sure to solve the leadership problems of most any organization. Though no longer an unknown model, servant leadership is seeing increased research through scholarly articles, dissertations, and books on this relatively new approach to leadership. Servant leadership is not based on a complicated set of guidelines; however, some basic tenets have been researched, studied and compiled by a host of scholars and popular speakers. It is interesting that, in spite of the extent of available literature, many people are unable to clearly define servant leadership. This presentation will contribute to defining servant leadership, explain its genesis and concepts, and offer the model as an option for effective leadership in organizations.

Keywords: Servant leadership, Leadership approaches; Organizational models, Servant leadership paradox; Servant leadership conceptualizations; Servant leadership characteristics; Servant leadership definitions

The title of the first chapter of George Barna's book (1997), *Leaders on Leadership: Wisdom, Advice, and Encouragement on the Art of Leading God's People*, is a concise statement of the significance of leadership. The title is, "Nothing is More Important than Leadership" (p. 17). Barna used the title of the chapter to stress the idea that the church of today is in decline due to a lack of leadership. Other organizational models are also facing a similar deterioration. Redmond

proposed that “needs of people would be met easier and more efficiently and with less ‘management’ if there were more leaders seeking to serve others” (Redmond, 1995, p. 30).

This paper will examine servant leadership from a variety of viewpoints. The volume of research into servant leadership as a viable model of leadership is increasing each year. Servant leadership is a relatively popular topic for many dissertations in a variety of fields. It is also interesting to consider servant leadership in comparison with other, more established, leadership models. Numerous research studies have focused on such relationships between theories.

Servant leadership is often associated with Christian leadership and Christian leaders; however, the model is not limited to the Christian realm. Such well-known organizations as 7-Eleven, TD Industries, Southwest Airlines, Herman Miller, and ServiceMaster embrace the servant leadership model. Herman Miller’s website explains the notion of servant leadership:

At Herman Miller, we respect each other as we are and focus on who we will become. Our culture represents the collective attitudes, aspirations, ideas, and experiences of the people who work here (<http://www.hermanmiller.com/about-us/things-that-matter-to-us.html>).

A review of Herman Miller’s values gives further evidence of the company’s focus on servant leadership. The identified values are operational excellence; better world report; environmental advocacy; inclusiveness and diversity; health and well-being; and community service.

1. DEFINITIONS AND DEVELOPMENT OF SERVANT LEADERSHIP

Understanding servant leadership is greatly aided by understanding the terms servant and service. The dictionary definitions of servant have many dimensions:

1. one who serves, or does services, voluntarily or on compulsion; a person who is employed by another for menial offices, or for other labor, and is subject to his command; a person who labors or exerts himself for the benefit of another, his master or employer; a subordinate helper
2. a person in the service of another
3. one who expresses submission, recognizance, or debt to another
4. a person working in the service of another
5. in a subordinate position
6. a person who is hired to work for another

Likewise, the definitions of the word service take several approaches:

1. An act of assistance or benefit; a favor
2. an act of helpful activity; help; aid.
3. work done by one person or group that benefits another
4. The performance of work or duties for a superior or as a servant
5. be of service, to be helpful or useful (Dictionary, 2011)

The concept of servant leadership, as developed by Robert Greenleaf, has given attention to the topic of servant leadership. The leader as a servant has historical origins back to biblical days, though this has not been a concept understood or practiced by many. Greenleaf’s conception of servant leadership has brought about significant change in the philosophy of leadership and management in numerous arenas of the secular business world. In describing the qualities of a leader, DePree insisted, “Above all, leadership is a position of servanthood” (1997, p. 220).

There is no one better to define servant leadership than Robert Greenleaf himself. In

The Servant as Leader, Greenleaf (1991) described the servant leaders in this manner, “The servant leader is servant first ... It begins with the natural feeling that one wants to serve first. Then conscious choice brings one to aspire to lead” (p. 7). For Greenleaf, “servant leadership means serving others and placing the good of others and the organization above the leader's self-interest” (Banks & Ledbetter, 2004, p. 108).

2 DIMENSIONS, CONCEPTUALIZATIONS, AND PARADOX OF SERVANT LEADERSHIP

Greenleaf's servant leadership concept has infiltrated a significant number of management and leadership sectors. A transformation is experienced by many after learning of the servant approach to leadership. There is a sense in which the servant leader is given permission to serve and meet the needs of others. Though often in practice in secular business settings, servant leadership also brings a spiritual dimension to management and leadership (Rieser, 1995). For some, the spiritual side of servant leadership is part of its appeal, especially when examined in the context of more prevailing societal trends. Even in some business environments, spiritual and religious discussions have a level of acceptance and do not necessarily create animosity among coworkers (Lee & Zemke 1993).

Most leadership models can be observed in the workplace and then explained in behavioral terms. Servant leadership differs from other models in that servant leadership comes from within the leader, surfacing out of the leader's principles, values, and beliefs. The servant leader's motivation and behavior come exclusively from the personal principles, values, and beliefs of the leader. It is through service to others that the servant leader seeks to achieve organizational goals (Farling, Stone, & Winston, 1999).

The conceptualizations of servant leadership are extremely varied. People who have been exposed to the idea of servant leadership might describe the model in any number of ways. Research on servant leadership includes several attempts to conceptualize the term. The concept of servant leadership finds its roots as far back in history as 600 B.C. At about this time, a Chinese Philosopher Lao Tzu expressed his idea about servant leadership by writing that the greatest leader forgets himself and attends to the development of others (Lichtenwalner, 2011). Biblical concepts of servant leadership are described in many passages of Scripture, though none of these passages are noted with the term “servant leadership.”

Robert Greenleaf gave much attention to the conceptualization of servant leadership in his writings. Larry Spears (2004), former president of the Greenleaf Center for Servant Leadership, offered many explanations of ten of Greenleaf's most prominent characteristics that enhance an understanding of the concept of servant leadership. Spears' list of characteristics included listening, empathy, healing, awareness, persuasion, conceptualization, foresight, stewardship, commitment to the growth of people, and building community.

Laub (1999) identified six scales of servant leadership that can provide a comprehensive model within which to identify specific characterizations. Many of the elements of Laub's scales are consistent with those identified by Greenleaf and those writings based on Greenleaf's model. The categories suggested by Laub are values people, develops people, builds community, displays authenticity, provides leadership, and shares leadership (Laub, p. 83).

Servant leadership is not an oxymoron; however, it is a paradox. The entire principle of Servant leadership was developed in the framework of Greenleaf's notion that the sole reason for the leader's existence is to serve the followers. As Lee explained, ‘It does stand the traditional

view of the leader—the CEO at the peak of the pyramid, the captain at the helm of the ship—on its head” (Lee & Zemke, 1993, p. 28). Servant leadership is dependent upon the blending of being a leader and being a servant. Servant leadership is not a concept of either/or; instead, the concept is both/and. “In the end, being a servant leader is not something you do but rather something you are” (DeGraaf, et al, 2001, p. 27).

3 SERVANT LEADERS: BORN OR MADE?

Gardner made a dogmatic statement about the prospect of leaders being born or made. When the question of servant leaders being born or made was rephrased to ask if servant leadership can be taught, Gardner (1990) gave another dogmatic answer—yes! He found that it is reasonable to believe that servant leadership can be taught because leadership itself can be taught. Servant leadership includes many of the same elements found in leadership.

Other researchers are not as quick to agree to an answer to this prevalent question. Rost (1991) suggested that a number of leadership concepts make the assumption that leaders are made, not born, but he pointed out that this could be too narrow a view. Maintaining such a stance does not consider the growth process of the leader. Ndoria (2004) stressed that there is much to be learned by studying the application of the various theories and approaches to leadership. She offered an example regarding transformational leadership.

Servant leadership recognizes awareness as a key mechanism for leadership development. Considering the development of servant leaders, Greenleaf (1970) suggested that “awareness . . . strengthens one's effectiveness as a leader.” The sign of an effective servant leader is whether or not the community the leader serves becomes “healthier, wiser, [and] freer.” Greenleaf also noted that leaders must learn how to view the act of leading as an act of serving followers (Greenleaf, p. 27).

4 MODEL COMPARISON

Comparison of varied models of servant leadership contributes to a more complete understanding of a conceptualization of servant leadership adaptable for the higher education environment. It should be noted that the conceptualizations of servant leadership are closely akin to traits, characteristics, and behaviors. In particular, a comparison of varied conceptualizations may serve as a fundamental basis for the development of a research instrument for use in the higher education setting.

Laub's six scales—values people, develops people, builds community, displays authenticity, provides leadership, and shares leadership—can be viewed as they relate to the characteristics forming the conceptualizations of servant leadership in the models described by Greenleaf, Spears, Farling, Stone, Winston, and Ingram.

The conceptualizations of servant leadership examined are not specific to higher education; however, one could argue for adoption of such characteristics among educators and administrations in the higher education setting.

Table 1 displays the comparison of five servant leadership models.

Table 1. Servant Leadership Model Comparison

Greenleaf	Laub	Spears	Farling, Stone, and Winston	Ingram
Healing	Values people	Healing	Trust	Acceptance
Service	Develops	Growth of	Service	Relationship

	people	people		
Ability to lead	Provides leadership	Empathy	Credibility	Credibility
Influence	Shares leadership	Awareness	Influence	Influence
Language and communication	Builds community	Building community	Vision	Vision
Foresight	Displays authenticity	Foresight		Encouragement
Listening		Listening		
Persuasion		Persuasion		
Priorities		Stewardship		
Conceptualizing		Conceptualizing		
Acceptance				
Values				
Vision				
Authority				
Power				
Trust				

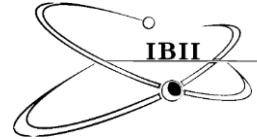
5 CONCLUSION

Understanding servant leadership is only the first step toward the practice of servant leadership. Today's service economy is consistent with servant leadership, but the concept takes service to a higher level. Students today are increasingly seeing themselves as consumers and customers—people who seek a service that higher education offers. Educators have the opportunity to meet the needs of students by teaching the disciplines in which they are experts and model for students a viable leadership example that can further prepare them for their vocational choices.

REFERENCES

- [1] Banks, R., & Ledbetter, B. (2004). *Reviewing leadership: A Christian evaluation of current approaches*. Grand Rapids, MI: Baker Academic.
- [2] Barna, G. (1997). *Leaders on leadership*. Ventura, CA: Regal Books.
- [3] DeGraaf, D, Tilley, C., & Neal, L. (2001). *Servant leadership characteristics in organizational life*. Indianapolis, IN: The Robert K. Greenleaf Center.
- [4] DePree, M. (1997). *Leading without power: Finding hope in serving community*. Holland, MI. Shepherd Foundation.
- [5] Farling, M., Stone, A., & Winston, B. (1999, WinterSpring). Servant leadership: Setting the stage for empirical research. *Journal for Leadership Studies* 6(1/2), 4972.

- [6] Gardner, J. (1990). *On leadership*. New York, NY: Free Press.
- [7] Greenleaf, R. (1970). *The servant as leader*. Indianapolis, IN: The Robert Greenleaf Center.
- [8] Greenleaf, R. (1991). *The servant as leader*. Indianapolis, IN: The Robert K. Greenleaf Center.
- [9] Ingram, O. (2003). *The conceptualization and perception of servant leadership in Christian higher education*. (Doctoral dissertation). Louisville, KY: Southern Baptist Theological Seminary.
- [10] Laub, J. (1999). *Assessing the servant organization: Development of the servant organizational Leadership assessment instrument*. (Unpublished doctoral dissertation). Florida Atlantic University, Boca Raton, FL.
- [11] Lee, C., & Zemke, R. (1993). The search for spirit in the workplace. *Training*. 6(6), 2129.
- [12] Lichtenwalner, B. (2011). *Resources for the beginning servant leader*. Retrieved from <http://modernservantleader.com/resources/resourcesforthebeginningservantleader/>
- [13] Miller, Herman (n.d.) Things that matter to us. Retrieved from <http://www.hermanmiller.com/about-us/things-that-matter-to-us.html>
- [14] Ndoria, J. (2004). Servant leadership: A natural inclination or a taught behavior. *Servant Leadership Research Roundtable*. Virginia Beach, VA: Regent University.
- [15] Redmond, B. (1995). *Biblical foundations for developing a servant mindset*. (Unpublished master's thesis). Moody Bible Institute, Chicago, IL.
- [16] Rieser, C. (1995). Claiming servantleadership as your heritage. In L. Spears (Ed.), *Reflections on leadership: How Robert K. Greenleaf's theory of servant leadership influenced today's top management thinkers* (pp. 4960). New York, NY: John Wiley & Sons.
- [17] Rost, J. (1991). *Leadership for the twentyfirst century*. New York, NY: Praeger.
- [18] Servant. (2011). In *Dictionary.com*. Retrieved from <http://dictionary.reference.com/browse/Servant>
- [19] Spears, L. (2004). *Practicing servant leadership: Succeeding through trust, bravery, and forgiveness*. San Francisco, CA: JosseyBass.



Effort, Depth, Satisfaction, and Resilience across the Spectrum of Online-to-Offline Relationships

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ABSTRACT

The aim of this study is to explore the differences across the spectrum of digital and in-person relationships, which is more true to the actual social experience of young adults than most of the available research in this area, which tends to falsely dichotomize relationships as “online” or “offline.” The authors measured perceived relationship depth, effort, satisfaction, and resilience for as many relationships as participants chose to list across five categories: primarily in-person, primarily digital, combined in-person and digital, formerly in-person, and formerly-digital. Moderate, positive relationships were found among all variables across all relationship types, indicating that these are not independent constructs and are all important in understanding relationships of any kind. Those relationships with a strong, current in-person component (primarily in-person and combined) were rated as significantly deeper, more satisfying, more resilient, and requiring more effort than those without. Currently digital relationships (e.g., face-to-face friendships that had since transitioned to primarily online communication) consistently represented a middle ground between the high in-person contact and low in-person contact relationships, which substantiates the conceptualization of relationships along a continuum of online to offline. Interesting findings related to gender and relationship type (e.g., friend, relative) were also found.

Keywords: Online relationships; Offline relationships; Depth; Effort; Satisfaction; Resilience

1. INTRODUCTION

With the advent and growth in popularity of digital forms of communication, a substantially different way of initiating and maintaining relationships was born. Social networking sites (e.g.,

Facebook, Myspace), texting, and other digital communication (e.g., tweeting) form the basis for or contribute to the maintenance of a substantial number of relationships, especially among adolescents and young adults who are most familiar with the technology. The Pew Internet and American Life Project reports that 66% of adults use social networking sites (increased from 8% in 2005), including 86% of young adults (aged 18-29 years)¹, especially Facebook, which is the most popular social network in the United States and the fourth most visited website on the Internet².

Digitally mediated relationships tend to be large in number; for example, college students have a median of 300 Facebook friends and the numbers often reach the thousands³. The majority of these relationships are acquaintances, though the development of stranger-relationships and close relationships does occur⁴. This is likely because social networking sites are designed in a way that facilitates maintaining large networks of “weak tie” relationships (i.e., relationships that are bridged by association to another person); these technologies allow for cheap, easy, and efficient relationship maintenance⁵. Of note, while the reasons given for the use of social networking sites vary, about two thirds of users report that staying in touch with current friends and family is a main reason^{1, 6}. In addition, researchers find moderate overlap between online and offline relationships, as much as 50% for adults, meaning that some face-to-face relationships are represented online as well, and use patterns indicate that a primary application of social networking sites is to strengthen offline relationships^{6, 7, 8}. These data combine to underscore the idea that there are many types of digitally-mediated relationships, with varying purposes and patterns of communication.

Many studies have examined important differences in “online” versus “offline” relationships, especially in regards to the development of intimacy. Some researchers suggest that online (or “computer-mediated”) communications lack the sophistication and nuance of face-to-face communication, resulting in reduced intimacy⁹. However, others suggest that computer mediated communication involves less interpersonal risk, resulting in higher disclosures and increased intimacy¹⁰. One group hypothesized that such increased self-disclosure and increased access would promote intimacy, but found that face-to-face relationships were more intimate than virtual relationships¹¹. They also found that those participants categorized as “virtual relators” (i.e., those who had pursued computer-mediated relationships) reported less intimacy in their face-to-face relationships, suggesting that perhaps they seek intimacy in online relationships to an attempt to balance their relative lack of intimacy in offline relationships¹¹. Despite the bulk of research on relationship intimacy, there is little work published that addresses other differences in online and offline relationships, such as the effort expended, the satisfaction derived, the perceived depth, or the resilience of these relationships.

Regarding effort, digital communication reduces the effort involved in maintaining relationships, especially the relatively superficial relationships so prevalent on social networking sites⁵. For example, Facebook users employ patterns of communication that involve less time- and effort-consuming methods of contact (e.g., playing games rather than writing a post on their wall) with newly acquired “friends”¹².

Virtually no published work describes the relational depth of online relationships, as the authors define it (“intense, serious, complex”); perhaps this concept has been passed over in favor of communicative (self-disclosure) or emotional intimacy. As noted above, the data on this is mixed, but generally findings indicate that there is often more self-disclosure but less perceived intimacy in online relationships than offline, in-person relationships.

With regard to relationship satisfaction, the concept of sociability implies that perceived social connectedness, regardless of relationship depth, is inherently enjoyable and increases satisfaction with social relationships overall and that these benefits are derived in a variety of exchange forms¹³. When applied to computer-mediated relationships, which often vastly outnumber face-to-face relationships, this may have special implications due to the substantial increase in number of superficial contacts with others (e.g., brief comments on social networking sites, short texts, “liking” and “poking” on Facebook).

The above research and findings support the researching of on and off line relationships. Specifically, the current literature related to effort, depth, satisfaction and resilience. The variables will be used to create a hypothesis encompassing the majority of the afore mentioned research studies. This research study is based on a theoretical framework, where the variables such as effort and satisfaction are measured and compared across relationship types to better explore the intricacies and confluence of these variables.

1.1 Hypothesis

The aim of this study is to explore the differences across the spectrum of digital and in-person relationships, which is more true to the actual social experience of young adults than most of the available research in this area, which tends to falsely dichotomize relationships as “online” or “offline.” Specifically, we are interested in the levels of perceived depth and effort in various types of relationships and how those factors relate to perceived satisfaction and resilience in relationships.

We expect to find positive relationships among all the primary variables, across all types of relationships. Specifically, we expect strong positive relationships between effort and depth, strong positive relationships between depth and resilience, and a weak positive relationship between depth and satisfaction. We further expect that those relationships with a strong face-to-face component will be perceived as requiring more effort, and being deeper, more satisfying, and more resilient. However, we do not expect there to be significant differences in total satisfaction gained from relationships, across type (i.e., the sum of satisfaction from all in Person relationships will be about equal to the sum of satisfaction from all combined relationships, or all currently digital relationships; see figure 1).

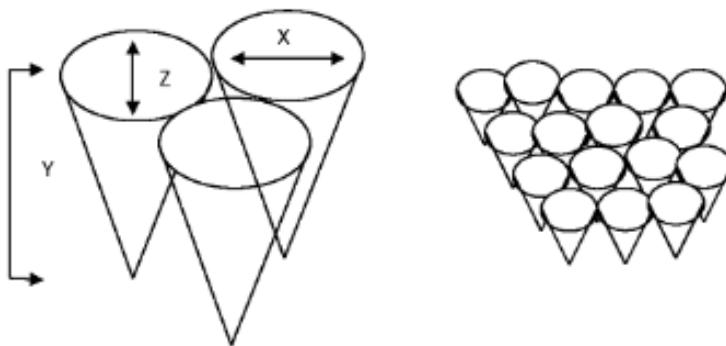


Fig. 1: Conceptualization of Relationships and Influential Factors

In this figure, each cone represents one relationship. The X axis represents satisfaction, the Z axis represents effort, and the Y axis represents relationship depth. Note on the left figure, this represents 3 relationships of significant effort and satisfaction with substantial depth. The right figure represents many relationships, none of which are very deep, but which cumulatively result

in about the same amount of satisfaction and require about the same amount of effort as the 3 relationships on the left.

2. METHOD

2.1 Participants

Two hundred college students (undergraduate and graduate) were recruited from a small, Southern university. The sample was 64% female. Average age was 21.3 years old ($SD = 8.13$). All participants reported familiarity with online communication (e.g., texting, tweeting) and social networking websites (e.g., Facebook, Myspace).

2.2 Participants

The survey packet included basic demographic information, basic definitions of important terms, and rating scales for different types of relationships, including: (1) Primarily Digital Relationships (PD; people with whom the predominate mode of communication is online (e.g., Facebook, texting, tweeting) and with whom there is little face-to-face contact), (2) Primarily In-Person (PIP; people with whom the predominate mode of communication is face-to-face, and with whom there is little to no online communication), (3) Combined (Digital and In Person) Relationships (D+IP; people with whom there is a substantial amount of face-to-face and online interaction), (4) Currently Digital (CD; the origin of the relationship was face-to-face, but now communication is primarily online), and (5) Formerly Digital (FD; the origin of the relationship was online, but now face-to-face communication predominates). The order in which relationships were addressed was randomized to reduce confounding due to order effects or fatigue.

For each type of relationship, participants were asked to list the initials of as many people who fell into each category as they wished, up to 10. Earlier pilot study data indicated that 10 possible entries per relationship type did not demonstrate a ceiling effect and that more than 10 was intimidating to the participants. They were also asked to identify what kind of relationship it was (e.g., relative, friend, romance, coworker) and the gender. For each person they identified, they rated the relationship on effort, depth, satisfaction, and resilience. Each dimension was rated using a mark on a 97mm line, anchored on both ends (see figure 2). Scores were coded as number of millimeters from the left edge. Effort was defined as “the physical, mental, and emotional work exerted during your relationship.” Depth was defined as “involving intense, serious, complex interactions.” Satisfaction was defined as “happiness and fulfillment with the state of your relationship.” Resilience was defined as “the ability of your relationship to withstand conflict and persist across time and change.”

1. Initials: _____	Is this person a: Relative Classmate Friend Romantic Coworker Other: _____	Is this person: Male or female
No effort at all	_____	A huge amount of effort
Not deep at all	_____	Extremely deep
Not at all satisfying	_____	Completely satisfying
Not at all resilient	_____	Extremely resilient

Fig. 2: Sample Survey Section

2.3 Procedure

Survey packets were given to students, with approximately 20-30 minutes to complete the packet time. They were instructed to report on as many relationships in each category as they chose, based on which relationships came to mind first.

3 RESULT

The average number of total relationships recounted by participants was 13.21 ($SD = 6.03$). Best represented were Primarily In-Person ($X = 3.91$, $SD = 2.39$) relationships. This means, that on average, participants listed a total of 13 relationships and that of the 13 relationships listed, 4 of the relationships represented primarily in person, or face to face, relationships. Combined ($X = 3.33$, $SD = 2.31$), and Currently Digital ($X = 3.03$, $SD = 1.94$) relationships followed in terms of frequency. This means that of the relationships reported an average of approximately 3 of these relationships had components of a combined relationship, also known as relationships with both online and offline components. Further, on average, approximately 3 of the relationships reported by participants were classified, by the participant as being currently digital, indicating that however the relationship was initiated, the primary form of current connection was through an online format. Participants were less likely to describe as many Primarily Digital ($X = 2.02$, $SD = 1.83$) and least likely to report Formerly Digital ($X = 0.9$, $SD = 1.24$) relationships. On average, participants reported only 2 primarily digital relationships, meaning that the reported relationship was both started and maintained through online formats. Also of importance, very few relationships, one per participant on average, were able to list a relationship that was initiated through an online format and then brought into an offline format. These differences were significant, $F(4, 995) = 73.45$, $p < .001$, which indicates that significant difference exist between relationships that were initiated in an offline format from those relationships that were initiated with an online format.

The expected positive relationships between effort and depth (.478) and depth and resilience (.589) were found. However, the relationship between depth and satisfaction, which was expected to be weakly positive, was the strongest relationship (.667). As hypothesized, small to moderate positive relationships were found among all main variables (see table 1). These relationships among variables were nearly identical, even after dividing cases by type (e.g., Primarily In-Person; see tables 2-6).

Table 1. Main variable correlations across all cases (n=2651).

	Effort	Depth	Satisfaction	Resilience
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Effort	1	.478**	.312**	.317**
Depth		1	.667**	.589**
Satisfaction			1	.653**
Resilience				1

**. Pearson correlation is significant at the 0.01 level (2-tailed).

Table 2. Main variable correlations in Primarily Digital relationships (n=404).

	Effort	Depth	Satisfaction	Resilience
Effort	1	.519**	.286**	.258**
Depth		1	.605**	.496**
Satisfaction			1	.629**
Resilience				1

**. Pearson correlation is significant at the 0.01 level (2-tailed).

Table 3. Main variable correlations in Primarily In-Person relationships (n=785).

	Effort	Depth	Satisfaction	Resilience
Effort	1	.422**	.252**	.346**
Depth		1	.668**	.611**
Satisfaction			1	.652**
Resilience				1

**. Pearson correlation is significant at the 0.01 level (2-tailed).

Table 4. Main variable correlations in Combined In-Person and Digital relationships (n=671).

	Effort	Depth	Satisfaction	Resilience
Effort	1	.456**	.276**	.266**
Depth		1	.620**	.555**
Satisfaction			1	.592**
Resilience				1

**. Pearson correlation is significant at the 0.01 level (2-tailed).

Table 5. Main variable correlations in Currently Digital relationships (n=610).

	Effort	Depth	Satisfaction	Resilience
Effort	1	.465**	.272**	.209**
Depth		1	.624**	.521**
Satisfaction			1	.617**
Resilience				1

**. Pearson correlation is significant at the 0.01 level (2-tailed).

Table 6. Main variable correlations in Formerly Digital relationships (n=181).

	Effort	Depth	Satisfaction	Resilience
Effort	1	.345**	.244**	.307**
Depth		1	.654**	.552**
Satisfaction			1	.584**
Resilience				1

**. Pearson correlation is significant at the 0.01 level (2-tailed).

The expected differences among the different types of relationships were also found. Specifically, In-Person and Combined relationships were described as being significantly more effort than the other three types, $F(4, 2646) = 30.97, p < .001$. As to depth, In-Person and Combined relationships were rated as significantly deeper than Currently Digital relationships, and Primarily and Formerly Digital relationships were rated as the least deep, $F(4, 2646) = 61.18, p < .001$. The same pattern emerged for satisfaction, with In-Person and Combined rated as the most satisfying, followed by Currently Digital, followed by Primarily and Formerly Digital, $F(4, 2646) = 71.24, p < .001$. This pattern also held for resilience, $F(4, 2646) = 71.24, p < .001$.

Taken together, these findings begin to build a picture of the various kinds of relationships that supports the model in figure 1. That is, effort, satisfaction, and depth hold relatively constant relationships with each other. What varies across relationship type seems to be the overall quality of the relationship, with In-Person and Combined relationships showing higher total scores on all variables, and the digital-based relationships showing lower scores on all variables (see figure 3). These findings indicate even though more effort is exerted to maintain an offline relationship, there is a corresponding level of satisfaction and depth that are achieved. On the other hand, this study found that with the decreased the effort of digital relationships came decreased levels of satisfaction and depth of those relationships by the sample.

Some interesting findings emerged regarding gender. While males and females did not differ significantly in the number of relationships they described, females reported more effort across all types of relationships, $F(1, 192) = 5.70, p < .05$, and described their relationships as deeper across all types, $F(1, 192) = 6.51, p < .05$. This means that the research found, for this sample, that even though females self-reported exerting more effort into relationships, they also self-reported increased depth of those relationships when compared to their male counterparts. There were no overall differences in reported satisfaction or resilience. However, when inter-action with the relationship partner's gender was considered, a few interesting trends emerged. Males' relationships with other males were reported as the most satisfying, and females' relationships with males were the least satisfying, $F(1, 1507) = 7.543, p < .01$. Males' relationships with males were also rated as the most resilient, and males' relationships with females as least resilient, $F(1, 1507) = 16.359, p < .001$. No gender interaction effects for depth or effort were found.

Also of note were some significant differences among the reported category of relationship (e.g., relative, friend) regardless of primary type of communication. Romantic relationships were rated as more effort than all others, followed by relatives, and then others (i.e., friends, classmates, coworkers), $F(1, 1574) = 10.68, p < .001$. A similar pattern was seen for depth, with romances listed as the deepest, followed by relatives, then friends, then others, $F(1, 1574) = 16.23, p < .001$. Romantic partners and relatives were rated as the most satisfying relationships, followed by friends and coworkers, then classmates, $F(1, 1574) = 6.24, p < .001$. A slight but important variation on this pattern emerged for resilience, where relatives and romantic partners were rated as the most resilient, with a trend of relatives being the most resilient but no significant differences between them (the "blood is thicker than water" finding). Again, friends fell into the middle category, less resilient than relatives but not significantly less resilient than

romances. Coworkers and classmates were rated as least resilient. No significant interactions between the relationship category (e.g., relative, friend) and the relationship type (e.g., primarily digital, primarily in-person) were found.

3.1. Figure 3: Conical Representation of Average Participants Results

These cones represent the average participant's relationships, where the number of ones indicates the average number of relationships disclosed by the participants for each category. The cones are to scale with the X axis representing satisfaction, Y axis representing depth, and the Z axis representing effort (as in Figure 1).

4 CONCLUSION

Overall, the hypotheses that were able to be examined were supported. Effort, depth, satisfaction, and resilience appear to be inextricably related relationship variables, regardless of relationship type. However, the relationships with a strong in-person component have higher values in all categories – they require more effort, but are also higher in satisfaction, depth, and resilience. Primarily In-Person and Combined In-Person-and-Digital relationships seem to fall into this category; Currently Digital and Primarily Digital relationships seem to form another category. Of particular interest, Formerly Digital relationships (though they are now primarily in-person) have more in common with the primarily digital relationships than the primarily in-person relationships. This may offer some evidence in opposition to Social Information Processing Theory, which suggests that online relationships may take longer to develop than face-to-face relationships, but over time have the same qualities¹⁴ and instead suggests that what may be most important in determining the current quality of a relationship is how that relationship began.

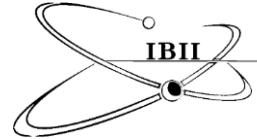
A particularly interesting finding relates to the Currently Digital category, which includes relationships with those people who a participant once knew primarily in person and at some point became primarily digital (e.g., former schoolmates, out-of-town relatives). These relationships were consistently found to be a “middle ground” between the relationships with a strong current face-to-face component and those that are primarily digital or have their roots in a digital origin. This may be related to research indicating that social similarity and number of joint activities and discussion topics are important factors in perceived closeness to online friends, over and above duration of the relationship¹⁵.

A significant limitation of this study was present in the format of the survey and administration procedure. Although the choice to have participants complete the survey in a limited time (as well as the necessarily limited number of potential responses) gave some interesting information about salience (i.e., the relationships that came to mind first), it did not give participants the opportunity to give a representative sample of their relationships. That is, the number of Primarily Digital relationships (e.g., Facebook friends) is likely quite substantially higher than the number of In-Person or Combined relationships that participants really have. This made it impossible to address the question of whether participants perceive the same amount of overall satisfaction from their higher number of less intimate and less satisfying online relationships and whether the sociability construct¹³ has strong applications here.

REFERENCES

- [1] Brenner J. (2012) Pew internet: Social networking (full detail). Washington, DC: Pew Internet & American Life Project.
- [2] Comscore. The 2010 U.S. digital year in review. Retrieved from http://www.comscore.com/Press_Events/Presentations_Whitepapers/2011/2010_US_Digital_Year_in_Review.
- [3] Ellison NB, Steinfield C, Lampe C. Connection strategies: Social capital implications of Facebook-enabled communication practices. *New Media & Society* 2011; 13: 873– 892. doi:10.1177/1461444810385389
- [4] Manago AM, Taylor T, Greenfield, PM. Me and my 400 friends: The anatomy of college students' Facebook networks, their communication patterns, and well-being. *Developmental Psychology* 2012; 48: 369-380. doi: 10.1037/a0026338
- [5] Donath J, Boyd D. Public displays of connection. *BT Technology Journal* 2004; 22: 71-82
- [6] Reich SM, Subrahmanyam K, Espinoza G. Friending, IMing, and hanging out face-to-face: Overlap in adolescents' online and offline social networks. *Developmental Psychology* 2012; 48: 356-368
- [7] Hampton KN, Goulet L, Rainie L, Purcell K. (2011). Social networking sites and our lives: How people's trust, personal relationships, and civic and political involvement are connected to their use of social net-working sites and other technologies. Washington, DC: Pew Internet & American Life Project
- [8] Kujath CL. Facebook and MySpace: Complement or substitute for face-to-face interaction? *Cyberpsy-chology, Behavior, and Social Networking* 2011; 14: 75-78. doi: 10.1089/cyber.2009.0311
- [9] Kiesler S, Siegel J, McGuire TW. Social psychological aspects of computer-mediated communication. *American Psychologist* 1984; 39: 1123-1134
- [10] McKenna KYA, Green AS, Gleason MEJ. Relationship formation on the internet: What's the big attraction? *Journal of Social Issues* 2002; 58: 9-32
- [11] Scott VM, Mottarella KE, Lavooy MJ. Does virtual intimacy exist? A brief exploration into reported levels of intimacy in online relationships. *Cyberpsychology and Behavior* 2006; 9: 759-761
- [12] Hsu C, Wang C, Tai Y. The Closer the Relationship, the More the Interaction on Facebook? Investigating the Case of Taiwan Users. *CyberPsychology, Behavior & Social Networking* 2011; 14: 473-476. doi: 10.1089/cyber.2010.0267
- [13] Simmel G, Hughes EC. The sociology of sociability. *American Journal of Sociology* 1949; 55: 254-261. Retrieved from <http://www.jstor.org/stable/2771136>
- [14] Walther JB. Interpersonal effects in computer-mediated interaction: A relational perspective. *Communication Research* 1992; 19: 52-90

- [15] Mesch G, Talmud I. The quality of online and offline relationships: The role of multiplexity and duration of social relationships. *The Information Society* 2006; 22: 137-148. doi: 10.1080/01972240600677805



Measuring Servant Leadership: Tests of Discriminant and Convergent Validity of the Servant Leadership Survey

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ABSTRACT

The purpose of this study was to analyze the internal reliability, convergent and discriminant validity of the Servant Leadership Survey (SLS). Exploratory factor analysis of the SLS found that 5 of the 9 servant leadership scales were supported. Additional exploratory factor and correlational analyses were performed using the Servant Leadership Survey, Multifactor Leadership Questionnaire (MLQ) and the Leader Behavior Description Questionnaire (LBDQ). The participants in this study consisted of 128 graduate students enrolled in a leadership program in San Antonio, Houston, and Harlingen, Texas who completed the MLQ, LBDQ and the SLS. All participants were employed full time in a variety of organizations including for profit, non-profit and government organizations. Overall findings indicate that although all three instruments likely share an overarching leadership factor, the courage, forgiveness, humility and authenticity scales from the SLS are likely measuring a different aspect of leadership than those of the MLQ and LBDQ.

Keywords: Multifactor Leadership Questionnaire; Leader Behavior Description Questionnaire; Servant Leadership Survey; Convergent Validity, Discriminant Validity

1. INTRODUCTION

Servant leadership is becoming an increasingly popular philosophy in the field of leadership styles. As society demands an increase in ethical practices in organizations, servant leadership has come forth as an advantageous form of leadership because it focuses on supporting others, fostering honesty, and emphasizes bringing out the best in followers (Liden, et al., 2015).

Robert Greenleaf (1970) first explained the concept of servant leadership in his essay of The Servant as Leader. Greenleaf (1970) stated that: "The servant leader is servant first... It begins with the natural feeling that one wants to serve, to serve first. Then conscious choice brings one to aspire to lead." (p.6). He also noted that unlike other leaders whom lead first, servant leaders are not driven by the need of material possessions, or the satisfaction of attaining power (Greenleaf, 1970). Later, he provided two more additional written works to support his philosophy of servant leadership called The Institution as Servant (1972) and Trustees as Servants (1972).

Up until the mid-2000's, servant leadership was a popular philosophy but generally lacked a testable set of constructs. A step toward a more concrete definition occurred in 1995 with Spears' 10 aspects of servant leadership. In the 2000's, several researchers have built on those aspects and the writings of others to develop models and instruments to measure servant leadership.

Table 1 contains six models of servant leadership found in the peer-reviewed literature. Spears (1995, 1998) created a conceptual model, but no instrument to measure the 10 constructs he purports. Laub (1999) created an instrument called the *Organizational Leadership Assessment (OLA)*. Some details about the development are included in his doctoral dissertation, but insufficient information seems to exist in the peer-reviewed literature about the psychometric properties of the *OLA*. Consequently, the models advanced by Spears and by Laub are shown shaded. The four instruments in the non-shaded area of Table 1 have peer-reviewed articles that describe the development of the instruments.

Table 1. Models of Servant Leadership

Spears (1995, 1998)	Liden, Wayne, Zhao and Henderson (2008) SLS*	van Dierendonck and Nijtten (2011) SLS**
Aw areness Community Building Conceptualization Empathy Foresight Healing Helping People Grow Listening Persuasion Stew ardship	Emotional Healing Creating Value for the Community Helping Subordinates Grow and Succeed Conceptual Skills Putting Subordinates First Behaving Ethically Empow ering	Empow erment Standing Back Authenticity Interpersonal Acceptance Accountability Humility Courage Stew ardship
Laub (1999) ¹ OLA	Sendjaya, Sarros and Santora (2008) SLBS	Barbuto and Wheeler (2006) SLQ
Building Community Developing People	Voluntary Subordination Authentic Self	Altruistic Calling Wisdom

¹ There is an instrument associated with Laub's model. Laub developed the Organizational Leadership Assessment for his doctoral dissertation. He first developed a pool of questions based on his review of the literature on servant leadership. He then had between 14 and 25 experts who had written on or taught servant leadership at the university level participate in a three step Delphi process in order to add to the original pool of items and then rate those items on their importance. At the conclusion of the third iteration of the Delphi process, 74 potential items had been developed. Eighty items were then tested with 828 participants. Laub performed a series of exploratory factor analyses (EFA) on this data. Laub found that 27 items loaded on a single component called Organizational Assessment and 53 items loaded on a single component called Leadership Assessment. The eigenvalues from the exploratory factor analysis were not provided. The 23 items that loaded on Organizational Assessment had factor loadings between .40 and .71. The 57 items that loaded on Leadership Assessment had factor loadings between .46 and .73. No factor analytic evidence was provided to support unique subscales (first order) within the factor called Leadership Assessment. It is unclear how the items for each first order scale were assigned to each scale. After the EFA, the instrument was reduced from 74 to 60 questions to decrease the time it took to complete the instrument. No additional details were provided on how the 60 questions were selected.

Displaying Authenticity	Covenantal Relationship	Emotional Healing
Providing Leadership	Responsible Morality	Organizational Stewardship
Sharing Leadership	Transcendental Spirituality	Persuasive Mapping
Valuing People	Transforming Influence	

OLA - Organizational Leadership Assessment, SLQ - Servant Leadership Questionnaire

SLS* - Servant Leadership Scale, SLBS - Servant Leadership Behavior Scale

SLS** - Servant Leadership Survey

As theories develop, often instruments to measure the constructs that comprise those theories are also developed. Two of the psychometric properties that gradually become clearer with increased reporting on an instrument are convergent and discriminant validity.

Convergent and discriminant validity are considered subcategories of construct validity. In order to establish the construct validity, we need to show that both convergent and discriminant validity are demonstrated. Convergent validity means two measures of constructs that theoretically should be related, are in fact related. Convergent validity can be established if two similar measures of a construct correspond with one another by calculating correlation coefficient. Correlations between theoretically similar measures should be high, while correlations between theoretically dissimilar measures should be low.

Discriminant validity tests whether measures of constructs that theoretically should not be related to each other are, in fact not related. Discriminant validity applies to two dissimilar constructs that are easily differentiated. A successful evaluation of discriminant validity shows that a test of a concept is not highly correlated with other tests designed to measure theoretically different constructs.

The introduction and history of the servant leadership models were discussed in section one of this paper. Section two provides a literature review, and the methodology used in this study will be examined in section three. After those sections have been noted, the results and the conclusion will be addressed in sections four and five.

2. REVIEW OF THE LITERATURE

The Full Range Model

While there have been many contributions to the idea of transformational leadership, the theory was first fully described by Burns in 1978. In his seminal book, *Leadership*, Burns contrasted leaders who helped transform those they lead to those who tended to engage in quid pro quo relationships.² Burns envisioned transformational and transactional leadership as separate entities. He also tended to write more about political leaders than organizational leaders.³ Burn's theory is thus a theory of political leadership defined by the properties of leader and followers but not by tasks (Anderson, 2016).

Nonetheless, his work formed an important foundation for the development of proceeding theories. Burns (1978) identified two types of leadership (transformative and transactional) on the basis of a qualitative analysis of the biographies of political leaders. Burns (1978) viewed the transformational leader as one who "engages with others in such a way that the leader and the follower raise one another to a higher level of motivation and morality" (p.20).

Bass (1985) built on the work of Burns. Bass moved the discussion of transformational leadership to comprise of a variety of organizational settings. Bass also envisioned transformational and transactional leadership on a continuum consisting of nine components, rather than as two separate entities. Furthermore, these components could also be broken down

² Burns, J. M. (1978). *Leadership*. New York: Harper and Row.

³ The information from this summary primarily comes from Bass, B. M., and Bass, R. (2008). *The Bass handbook of leadership: Theory, research, and managerial applications*. New York: Free Press; and from Stogdill, R. M. (1963). *Manual for the Leader Behavior Description Questionnaire Form XII*. Columbus: Ohio State University, Bureau of Business Research.

into three categories on a continuum. Bass and Avolio operationalized this research by formulating the Full Range Model (FRL). Bass (1995) and his colleagues presented transformational leadership to encompass inspirational motivation (IM), idealized influence (II), intellectual stimulation (IS), and individualized consideration (IC), while transactional leadership contains contingent reward (CRW), and active management by exception (MBEA) (Hinkin et al., 2008). Passive- avoidant contains management by exception passive (MBEP) and laissez-faire (LF). Essentially the absence of leadership was conceptualized as being called laissez-faire (Hinkin et al., 2008).

Normally conceptualized as four dimensions, transformational leadership includes charisma or idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration (Bass, 1990). Leader attributes and behaviors that cause followers to relate to the leader can be referred to as idealized influence (Mathieu, et al., 2015). It can be further broken down into idealized influence attributed and idealized influence behavioral. Green (2013) defined idealized influence attributed as “related to believing that someone is a role model based on her or his credentials or reputation” (p.213). Whereas, idealized influence behavioral is more based upon observing the leader as a role model and wanting to emulate them. Individualized consideration is when the leader is giving specialized attention to the needs of the followers, providing unique treatment, and lending support when necessary so that the followers can realize their full potential (Bass, 1990, 1997). Intellectual stimulation calls for the analysis of problems in new ways, use of actions that challenge followers to comprehend, and conceptualize (Bass, 1990, 1997). Inspirational motivation is the clear communication of appealing goals through the use of enthusiasm, optimism, and setting of high expectations (Bass, 1990, 1997).

Transactional leadership lies in the middle of the FRL continuum and is more inclusive of task oriented behaviors with the aspects of contingent reward and management-by-exception active. Contingent reward is based upon a reward provided to the follower when successfully completing a given task. Task-oriented behaviors are primarily concerned with executing tasks in a dependable and organized fashion (Michael, et. al., 2011). However, MBEA is more built upon the follower being “micromanaged” by their leader.

Passive avoidant leadership unfortunately falls on the opposite end of the continuum, and can be seen as the opposite of transformational leadership. Unlike MBEA, Northouse (2010) describes management-by-exception passive (or MBEP) as an approach where the leader intervenes only after issues emerge, or expectations have not been met. In their FRL model, which contains transformational, transactional, and laissez-faire forms of leadership, Bass and Avolio (1994) define laissez-faire leadership as: “... the avoidance or absence of leadership and is, by definition, the most inactive – as well as the most ineffective according to almost all research on the style” (p. 4). As opposed to transactional leadership, laissez-faire represents a non-transaction between the leader and the follower (Skogstad, et. al. 2014). Both transformational and transactional leadership can be regarded as an antithesis of laissez-faire leadership on an active-passive continuum for leader-follower exchanges (Bass & Avolio, 1994, p. 6).

Unlike transactional and transformational forms of leadership, laissez-faire leadership is recognized as leaders’ volitional and purposeful avoidance of subordinates when they are in need of support (Skogstad, et. al. 2014). Hence, laissez-faire leadership is readily distinguishable from transactional and transformational forms of leadership and composes a unique leadership form that should be further researched in its own right (Skogstad, et. al. 2014).

Over the past 15–20 years, transformational leadership has taken a commanding presence in leadership studies (Balwant, 2016). This style of leadership is often referred to as “the new leadership” theory or the “new paradigm” approach (Bryman, 1992). The term transformational is often used interchangeably with some of its dimensions, such as visionary, charismatic, or value-based in the literature (Anderson, Ones, Sinangil, & Viswesvaran, 2001). Charisma, derived from the Greek word meaning “favored” or “gifted” (Johns & Saks, 2007), can be defined as a leader that emphasizes trust, cultivates commitment to success, gains respect, earns trust, and articulates a sense of mission (Bass, 1990, 1997). A transformational leader can be described as an individual who “articulates a realistic vision of the future that can be shared, stimulates subordinates intellectually, and pays attention to the differences among the subordinates” (Yammarino & Bass, 1988, p. 2).

Both transformational and transactional have been argued by Bass and colleagues as being the most effective leaders (Avolio, Bass, & Jung, 1999; Bass, 1998). Intrinsic motivation is a subordinate outcome that has been shown to be positively related to transformational leadership (Bono & Judge, 2003). Moreover, leader effectiveness and organizational performance has also been shown to be related to transformational leadership (Judge & Piccolo, 2004). Furthermore, various subordinate outcomes such as managerial satisfaction and effectiveness, extra effort, and organizational commitment are also positively related to contingent reward behaviors (Bass, 1998; Bycio et al., 1995; Judge & Piccolo, 2004; Lowe, Kroeck, & Sivasubramaniam, 1996). However, typically both MBEA and MBEP have a negative relationship with the previously noted outcomes (Bycio et al., 1995; Judge & Piccolo, 2004).

2.1 The Multifactor Leadership Questionnaire

The study of transformational leadership has continued and, in fact, has increased substantially in recent years since the development of these constructs (Dumdadum, Lowe, & Avolio, 2002). Developed by Bass and his associates, the *Multifactor Leadership Questionnaire (MLQ)* has been utilized by the vast majority of published empirical research on the topic (Bass, 1990; Bass & Avolio, 1990, 1994; Seltzer & Bass, 1990).

Additional improvements were made on the continuum of leader behaviors between 1985 and 1990 (Hater and Bass, 1988; Avolio and Bass, 1991; Avolio, Waldman, and Yammarino, 1991). By 1991, a nine-component model was developed and was supported by the *Multifactor Leadership Questionnaire 5X*. The *MLQ 5X* quantifies transformational, transactional, and avoidant leadership styles (Bagheri, et al. 2015). Consisting of 45 items in total, the first 36 items of the *MLQ 5X* measure the type of leadership style, and the remaining 9 items examine the effectiveness of the manager (Bagheri, et al. 2015). The model began to experience widespread use following Bass and Avolio’s 1994 book, *Improving Organizational Effectiveness through Transformational Leadership*.

Task and Relationship

The style approach to leadership emerged during the 1950s. Unlike the FRL model that focuses on transforming the follower to greater heights, the style approach highlights the importance of the leader and his/her behaviors. According to Northouse (2010) researchers determined that this approach consisted of two aspects: task behaviors and relationship behaviors (p. 69). Task behaviors are considered those that focus on accomplishing goals, while relationship behaviors are centered on the level of comfort the followers have with themselves,

others within the organization and also with the situations that may arise (Northouse, 2010. p. 69.)

A lot of research has been done pertaining to the style approach. Ohio State University in the 1940s were one of the first to investigate this form of leadership. Green (2013) revealed that, "both the Ohio State and Michigan streams of research conceived of dimensions of leadership related to Taking Care of Business (Initiating Structure, Production Orientation) and Taking Care of Followers (Consideration, Employee Orientation)" (p. 81). As far as the potential performance of employees is concerned, leadership effectiveness is vital (Morrison, 2010). Leaders should place significance on the capacity of followers to adapt to the external competitive surroundings and changing their form of leadership (Hersey, Blanchard, & Johnson, 2001).

2.2 The Leader Behavior Description Questionnaire XII

The instrument used to measure initiation of structure and consideration is the *Leader Behavior Questionnaire XII*. The *Leader Behavior Description Questionnaire XII* which was developed as a result of research conducted by researchers at Ohio State, consists of 100 questions and measures two types of leader behaviors: initiating structure and consideration (Northouse, 2010, p. 70). Green (2013) notes that the most recent version, the *LBDQ-XII*, consists of 100 questions that measure 12 dimensions and "has been used in over 30 peer-reviewed articles and over 600 dissertations" (p. 76). A search of databases such as Academic Search Premier or Business Source Complete will return over 270 peer reviewed articles that have used the instrument.

Hemphill and colleagues at The Ohio State University brainstormed 1,800 possible leader behaviors, and then selected 150 behaviors they believed could be uniquely assigned to subscales.⁴ Factor Analyses indicated that the questions loaded on two main components: consideration and initiation of structure. This produced the original *Leader Behavior Description Questionnaire* that had 40 questions and measured these two leader dimensions.

Additional work continued to develop more subscales that were related to initiation of structure and consideration, yet were also different. Through additional factor analyses, this research produced the twelve scales of the *LBDQ-XII*. Nine different reliability studies were conducted on groups of army members, highway patrol members, aircraft executives, ministers, community leaders, corporation presidents, labor presidents, college presidents and senators. The Kuder-Richardson measure of internal reliability was calculated for each of these nine samples. Similar to a Cronbach Alpha score, the Kuder-Richardson score ranges from 0 to 1. The closer the score is to 1, the more internally consistent the questions. The Kuder-Richardson scores for each of the 12 subscales for each of the nine samples generally fell between 0.54 and 0.8⁵.

2.3 The Servant Leadership Survey

Using expert acumen and an extensive literature review, the *Servant Leadership Survey* underwent three steps and eight samples in its development, and 99 items were generated (van Dierendonck and Nuijten, 2010). The 1,571 participants used were employed with a variety of occupational experiences. Dirk van Dierendonck and Inge Nuijten (2010) conducted their

⁴ The information from this summary primarily comes from Bass, B. M., and Bass, R. (2008). *The Bass handbook of leadership: Theory, research, and managerial applications*. New York: Free Press; and from Stogdill, R. M. (1963). Manual for the Leader Behavior Description Questionnaire Form XII. Columbus: Ohio State University, Bureau of Business Research.

⁵ LBDQ User's Manual (1963).

3	IM	.64**	.63**													
4	IS	.50*	.47**	.56**												
5	IC	.55*	.46**	.48**	.53**											
6	CR	.58*	.60**	.53**	.48**	.55**										
7	MBEA	.04	.14	-.03	.16	.06	.30**									
8	MBEP	-.12	-.08	-.44**	-.28**	-.17	-.07	.05								
9	LF	-.11	-.12	-.34**	-.18*	-.13	-.11	.13	.55**							
10	Consideration	.15	.29**	.11	.28**	.28**	.18*	.10	.08	-.05						
11	Init. Structure	.09	.22*	.10	.20*	.16	.19*	.13	.09	-.05	.59**					
12	Empowerment	.37**	.28**	.39**	.24**	.35**	.46**	.08	-.11	-.05	.11	.11				
13	Humility	.16	.05	.20*	.13	.19*	.15	.06	-.07	-.11	-.03	-.03	.29**			
14	Authenticity	.10	.12	.06	.00	.07	.20*	.08	-.04	.03	-.09	.01	.24**	.28**		
15	Courage	.22*	.13	.20*	.15	.02	.10	-.02	-.07	.09	-.02	.08	.20*	.08	.29**	
16	Forgiveness	-.01	-.06	.15	.08	.14	-.02	-.13	-.27**	-.33**	-.03	-.19*	-.02	.08	-.10	.29**

Note. * $p < .05$. ** $p < .01$.

3.2 Initial Exploratory Factor Analysis of the Servant Leadership Scale (SLS)

An initial exploratory factor analysis of the *SLS* was conducted using the principle components method and varimax rotation. Nine components were found with eigenvalues greater than 1. Table 3 contains the factor loadings for each scale. Factor loadings greater than .4 are shown in bold.

Components 1 - Empowerment, 3 - Humility, 5 - Authenticity, 7 – Courage, and 8 – Forgiveness loaded approximately as the scoring directions indicate. The other questions' loading on components 2 and 4 were a mix of questions, priori-theorized to load on accountability, stepping back and stewardship. Those questions failed to load on a component that approximated the theory.

Table 3. Components Found in Exploratory Factor Analysis

Question Type	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Emp1	Mix	Hum	Mix	Auth	Emp2	Cour	Forg	None
Empowerment	0.84	-0.06	0.09	0.10	0.12	0.11	0.07	-0.07	0.06
Empowerment	0.81	0.16	0.05	0.09	0.12	0.11	0.03	-0.07	-0.01
Empowerment	0.73	0.23	0.25	0.30	0.08	0.12	-0.01	0.00	-0.07
Empowerment	0.55	0.23	0.02	0.15	0.25	0.02	0.18	0.12	-0.41
Accountability	0.11	0.84	-0.05	0.09	0.07	0.02	0.07	0.02	-0.04
Humility	0.03	0.65	0.09	-0.02	0.29	0.16	-0.14	0.11	0.00
Accountability	0.05	0.62	0.28	0.12	-0.10	0.12	0.39	-0.06	0.23

Stepping Back	0.22	0.48	0.14	0.27	-0.09	0.42	-0.18	0.02	-0.30
Stewardship	0.21	0.44	0.14	0.39	0.27	-0.20	0.17	-0.07	-0.24
Humility	0.09	-0.04	0.85	0.13	0.16	0.06	0.06	-0.05	0.10
Humility	0.27	0.11	0.81	-0.05	0.02	-0.03	0.04	-0.07	-0.08
Humility	-0.02	0.13	0.80	0.06	0.13	0.07	0.04	0.08	-0.06
Stepping Back	-0.08	0.19	0.40	0.41	-0.03	0.36	-0.27	-0.21	-0.02
Stewardship	0.17	0.06	0.05	0.77	-0.01	0.07	0.13	-0.13	0.08
Authenticity	0.15	0.08	0.03	0.73	0.22	0.03	0.10	0.13	-0.13
Empowerment	0.39	0.41	0.21	0.47	-0.03	0.04	-0.05	-0.07	0.20
Authenticity	0.24	0.07	0.10	-0.08	0.71	0.06	0.08	-0.10	0.10
Authenticity	0.06	0.12	0.06	0.20	0.66	0.19	0.05	0.06	-0.10
Humility	0.12	0.10	0.37	0.24	0.53	0.04	0.16	-0.14	0.06
Authenticity	-0.35	0.03	0.03	-0.01	0.41	0.28	0.16	0.42	0.18
Stepping Back	0.05	0.00	0.07	0.05	0.17	0.81	0.04	0.10	-0.20
Empowerment	0.36	0.36	0.07	-0.03	0.05	0.61	0.24	-0.18	0.10
Empowerment	0.21	0.08	-0.05	0.07	0.17	0.59	0.32	-0.17	0.30
Courage	0.07	-0.01	0.02	0.01	0.11	0.06	0.80	0.17	-0.15
Courage	0.04	0.09	0.09	0.17	0.08	0.11	0.78	0.03	0.08
Forgiveness	0.02	0.09	-0.03	-0.08	-0.02	-0.13	0.07	0.83	0.05
Forgiveness	-0.17	-0.11	-0.07	0.11	-0.35	0.14	0.26	0.56	0.24
Forgiveness	-0.02	0.04	0.00	-0.01	0.11	-0.09	-0.05	0.46	0.73
Stewardship	0.28	0.37	0.05	0.31	0.17	0.16	0.25	0.17	-0.15
Accountability	0.22	0.39	0.28	0.26	0.36	-0.10	0.07	-0.30	0.03

Note. Rotated component matrix. Emp1 – Empowerment, Mix -Mix of Scales, Hum – Humility, Mix -Mix of Scales, Auth – Authenticity, Emp – Empowerment, Cour – Courage, Forg – Forgiveness, None – Questions failed to load with factor loading > .39

3.3 Definitions of SLS

There are eight dimensions or scales used to assess an individual taking the *SLS*, which were aforementioned in this article. Empowering is the first dimension, it can be defined as a motivational concept focused on enabling people and encouraging personal development (Conger, 2000). The second dimension or scale is accountability, which can be defined as people being held accountable or responsible for the actions that are within their control. Standing back is the third dimension or scale used. With this dimension, leaders give their followers/others priority while also seeing that they receive credit for their work that they perform. They also take a step back with their followers' work so it can be successfully completed.

Humility is the ability of the leader to place their abilities in proper perspective without allowing for one to focus on their inability to make errors, or perform poorly at their work. Authenticity is about being true to oneself by being able to illustrate a genuine nature to others

professionally, publicly, and privately. Courage can be seen as the ability to take risks and to be innovative and execute those newly developed approaches rather than continuing with antiquated ones. The ability to understand and experience the feelings of others, and the perspective that people are coming from can be identified as interpersonal acceptance (George, 2000). When one practices service instead of self-control and self-interest, and the willingness to take responsibility for the larger institution can be labeled as stewardship (Block, 1993).

The question in component 3 theorized to measure stepping back entailed a belief that one doesn't seek rewards for their behaviors toward others. This could well be interpreted as either a humility or stepping back question. The humility question that loaded with the authenticity questions in component 5 involved learning from another's viewpoint. A central part of the theory of authentic leadership involves balanced processing. Balanced processing involves listening to the ideas of others when making decisions, and possibly challenging your own beliefs because of this new found knowledge. The humor question in component 5 could also be interpreted as an authenticity question.

Based on the initial factor analysis, composite scores were created for empowerment, humility, authenticity, courage and forgiveness. These five components were included in an exploratory factor analysis that also included the nine components from the *Multifactor Leadership Questionnaire* and *Leader Behavior Description Questionnaire*. Table 4 provides the reliability estimates for the five component scores. Removing one question from the three questions that measure forgiveness improved the reliability from .35 to .50. For the factor analysis using the three instruments, the third forgiveness question was included in the forgiveness composite score.

Table 4. Reliability of Revised Scales

Variable	Cronbach Alpha	Revised Cronbach Alpha	Question Removed
Empowerment	.83		
Humility	.75		
Courage	.72		
Authenticity	.55		
Forgiveness	.35	.50	Forget past mistakes

4 RESULTS

A second exploratory factor analysis was run with the nine components measured by the *Multifactor Leadership Questionnaire (MLQ)*, *Leader Behavior Description Questionnaire (LBDQ)* and the revised components from the *Servant Leadership Survey (SLS)*.

4.1 Convergent Validity

The empowerment scale of the *SLS* loaded with the elements of transformational leadership in the exploratory factor analysis and was correlated in the range of .24 to .39 with these five aspects of transformational leadership. Interestingly, the empowerment scale was also moderately correlated with contingent reward, $r = .46$.

The empowerment questions combined into the empowerment scale in this study focused on leader behaviors to assist followers in growth and development. The contingent reward questions from the *MLQ* all include some sort of reward for the follower achieving results and meeting

performance goals. These broad constructs, assisting followers in growth and development from the *SLS* and rewarding followers for meeting goals seem to be interrelated.

The courage scale from the *SLS* didn't load with any of the leadership scores in the factor analysis. The courage scale was weakly correlated with the idealized influence attributed, idealized influence behavioral and inspirational motivation scores of the *MLQ*. In earlier versions of the *MLQ* these three scores were often combined to create a charisma score. The idea of leader courage and leader charisma being correlated makes conceptual sense.

The forgiveness questions from the *SLS* illustrated a weak negative correlation with the questions from the *MLQ*. Those questions in the *MLQ* made reference to management by exception, laissez-faire, and intellectual stimulation. Forgiveness and courage from the *SLS* also had a weak positive correlation with each other.

Humility questions from the *SLS* developed a weak positive correlation with individual consideration, individual stimulation, and contingent reward questions from the *MLQ*. The humility scale also had a weak positive correlation with another dimension on the same assessment of the *SLS* called empowerment.

Authenticity questions shared a weak positive correlation with contingent reward and intellectual stimulation from the *MLQ*. A weak positive correlation of authenticity scale on the *SLS* can also be seen as additional items on the same assessment with scales such as empowerment and humility. Table 5 below is the Exploratory Factor Analysis for multiple instruments.

Table 5. Multiple Instrument Exploratory Factor Analysis

	TF	PA	LBDQ	Auth-Hum	Cour-Forg
IIA	0.83	-0.03	-0.05	0.05	0.15
IIB	0.79	0.03	0.16	-0.01	0.11
CR	0.79	0.13	0.09	0.26	-0.06
IM	0.78	-0.41	-0.02	0.08	0.11
IC	0.72	-0.07	0.14	0.14	-0.18
IS	0.70	-0.18	0.20	0.01	-0.01
Empowerment	0.44	-0.01	0.04	0.52	0.10
LF	-0.11	0.80	-0.13	-0.07	0.17
MBEP	-0.18	0.79	0.08	-0.09	0.00
MBEA	0.17	0.43	0.18	0.29	-0.25
Initiation of Structure	0.10	0.03	0.88	0.02	0.13
Consideration	0.20	0.03	0.85	-0.07	-0.07
Humility	0.08	-0.11	-0.04	0.77	-0.11

Authenticity	0.01	0.02	-0.05	0.70	0.34
Courage	0.14	-0.06	-0.01	0.18	0.83
Forgiveness	0.04	-0.47	-0.15	0.04	0.61

Note. TF – elements of transformational leadership plus contingent reward and empowerment, PA – passive avoidant behaviors, *LBDQ* initiation of structure and consideration from the *LBDQ*, Auth-Him, questions from the hypothesized authentic and humility scales, Cour-Forg, questions from the hypothesized courage and forgiveness scales, Cour-Forg.

4.2 Discriminant Validity, SLS, MLQ and LBDQ

In the exploratory factor analysis, the humility, authenticity, courage and forgiveness sales loaded on different components than any of the *MLQ* or *LBDQ* scales. None of the correlations between the *SLS* scales and the *MLQ* or *LBDQ* scales were strongly correlated. This provides some sense that while there is likely an overarching leadership factor shared by all three instruments, the courage, forgiveness, humility and authenticity scales appear sufficiently unique from the *MLQ* and *LBDQ* scales that they are, indeed likely measuring a different aspect of leadership than either of those instruments.

4.3 SLS

As mentioned above, to establish convergent validity, we need to show that measures that should be related are indeed related. In above Table 3, we see, for instance, four empowerment measures (each is a question/item of *SLS*) that all purport to reflect the same construct-Empowerment (Component 1). We see the correlations of the four empowerment scale items are very high with the construct of Empowerment (in bold). This provides evidence that our theory that all four empowerment items are related to the same construct (Component 1) is supported.

To establish discriminant validity, we need to show that measures that should not be related are in reality not related. If we have discriminant validity, the relationship between measures from different constructs should be very low. In above Table 3, we again see that the four empowerment measures (each is a question/item of *SLS*) cross-construct (Component 2-8) correlations are very low (in light grey). This provides evidence of discriminant validity.

Convergent and discriminant validity can also be illustrated in Table 6. It shows in Table 6 for instance, elements of transformational leadership plus contingent reward and empowerment that all purport to reflect the construct of Transformation (Component 1 TF). We see the correlations of those items are very high (in bold) with the construct of TF (Component 1). This provides evidence that our theory that all elements of transformational leadership plus contingent reward and empowerment items are related to the same construct TF (Component 1) is supported.

For discriminant validity, in Table 6 it shows that measures that should not be related are in reality not related. If we have discriminant validity, the relationship between measures from different constructs should be very low. In addition, we again see elements of transformational leadership plus contingent reward and empowerment cross-construct (component 2-5) correlations are very low (in light grey) which provides evidence of discriminant validity.

The empowerment scale of the *SLS* loaded with the transformational leadership and contingent reward scales of the *MLQ*. Conceptually, this makes sense, as the nature of transformational leadership is to assist followers with growth and development. The second component of the factor analysis was three “ineffective” scales of the *MLQ*. Over its 30-year history there were

iterations of the *MLQ* that combined these same three scales into a second order scale called Laissez-Faire. The third component consisted of the scales from the *LBDQ*.

The fourth component consisted of the authenticity and humility scales from the *SLS*. Two questions from the authenticity scale concerned learning from others and expressing limitations. Three of the humility questions were related to learning from criticism.

Both components seem to be capturing a sense of communicating openly with others, and learning from criticism. These are likely conceptually related as others are often unwilling to provide constructive criticism to someone if she/he is unwilling to be open to those critiques. The final component consisted of courage and forgiveness. Both courage questions focus on risk taking. The forgiveness questions focused on restraining from criticism of workers' mistakes and forgiving and forgetting others' mistakes.

Table 6. Convergent and Discriminant Validity from Correlation Matrix

Scale	IIA	IIB	IM	IS	IC	CR	MP	LF	IS	Emp	Cou	For	Hum	Aut
Empowerment														
Courage														
Forgiveness														
Humility														
Authenticity														

Note. Dark squares are moderate, positive correlations. Light grey squares are weak positive correlations. Diagonal squares are weak negative correlations.

5 CONCLUSION

The servant leadership survey appears to be measuring something different from the other assessments. Being that there appears to be convergent validity, this instrument can be definitely used for an organization or as a leader to assess the dimensions of servant leadership.

Perhaps this convergent validity is due partially to the sample of this study being a convenience sample. This sample was primarily taken from PhD students. As a result, these findings could have been somewhat skewed. However, a rebuttal to this argument can also be made that these PhD students varied in occupations that were profit and non-profit organizations, professional specializations, and other demographics. Therefore, this initial argument cannot necessarily be negated, but it can be somewhat weakened.

Unfortunately, researchers may not be able to use the *SLS* interchangeably with the *MLQ* and *LBDQ*, or use the *MLQ* to test for the *SLS*. By taking these assessments separately, an individual utilizing these instruments will gain far more knowledge about themselves as a leader or another person that is being assessed. This additional understanding can be used to develop the leadership style of that individual taking the instrument. By having this insight, a leader can modify his or her leadership style to better suit the needs of his or her followers.

In conclusion, overall findings indicate that although all three instruments likely share an overarching leadership factor, the *SLS* scales of courage, forgiveness, humility and authenticity are likely measuring a different aspect of leadership than those of the *MLQ* and *LBDQ*.

REFERENCES

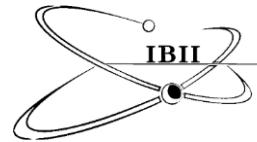
- [1] Andersen, J. A., *An Old Man and The “Sea of Leadership”*. JOURNAL OF LEADERSHIP STUDIES, Vol.9, No. 4, pp. 70–81, 2016, DOI: 10.1002/jls.21422.
- [2] Anderson, N., Ones, D. S., Sinangil, H. K., & Viswesvaran, C., *Handbook of industrial, work & organizational psychology* (Vol. 2). Sage, Thousand Oaks, CA, 2001.
- [3] Avolio, B. J., Bass, B. M., & Jung, D. I. (1999). Re-examining the components of transformational and transactional leadership using the Multifactor Leadership Questionnaire. *Journal of Occupational and Organizational Psychology*, 72, 441-462.
- [4] Bagheri R, Sohrabi Z, & Moradi E, *Psychometric properties of Persian version of the multifactor leadership questionnaire (MLQ)*. MEDICAL JOURNAL OF THE ISLAMIC OF IRAN, Vol. 29, p. 256, 2015.
- [5] Balwant, P. T., *Transformational Instructor-Leadership in Higher Education Teaching: A Meta-Analytic Review and Research Agenda*. JOURNAL OF LEADERSHIP STUDIES, Vol. 9, No.4, pp. 20–42, 2016, DOI: 10.1002/jls.21423.
- [6] Barbuto Jr., J. E., & Wheeler, D. W., *Scale development and construct clarification of servant leadership*. GROUP & ORGANIZATION MANAGEMENT, Vol. 31, No. 3, pp. 300-326, 2006.
- [7] Bass, B. M. (1985). *Leadership and performance beyond expectation*. New York: Free Press.
- [8] Bass, B. M., *From transactional to transformational leadership: Learning to share the vision*. ORGANIZATIONAL DYNAMICS, Vol. 18, No. 3, pp. 19 – 31, 1990, DOI: 10.1016/0090-2616(90)90061-S.
- [9] Bass, B. M., & Avolio, B. J., *Multifactor leadership questionnaire*, Consulting Psychologists Press, Palo Alto, 1990.
- [10] Bass, B. M., & Avolio, B. J., *Improving Organizational Effectiveness Through Transformational Leadership*, Sage, Thousand Oaks, CA, 1994.
- [11] Bass, B. M., & Avolio, B. J. (1995). The multifactor leadership questionnaire – 5x short form. Redwood: Mind Garden.
- [12] Bass, B. M. (1998). *Transformational leadership: Industrial, military, and educational impact*. Mahwah, NJ: Lawrence Erlbaum.

- [13] Bass, B. M., *Does the transactional-transformational leadership paradigm transcend organizational and national boundaries?* AMERICAN PSYCHOLOGIST, Vol. 52, No. 2, pp. 130 – 139, 1997, DOI: 10.1037/0003-066X.52.2.130
- [14] Block, P., *Stewardship: Choosing Service over Self-Interest*, Barrett-Koehler, San Francisco, 1993.
- [15] Bono, J. E., & Judge, T. A. (2003). Self-concordance at work: Toward understanding the motivational effects of transformational leaders. *Academy of Management Journal*, 46, 554-571. Processes, 97, 117-134.
- [16] Brown, M. E., Treviño, L. K., & Harrison, D., *Ethical leadership: A social learning perspective for construct development and testing*. ORGANIZATIONAL BEHAVIOR AND HUMAN DECISION PROCESSES, Vol. 97, pp. 117-134, 2005.
- [17] Bryman, A., *Charisma and Leadership in Organizations*, Sage, England, 1992.
- [18] Burns, J. M. G., *Leadership*, Harper & Row, New York, 1978.
- [19] Bycio, P., Hackett, R. D., & Allen, J. S. (1995). Further assessments of Bass's (1985) conceptualization of transactional and transformational leadership. *Journal of Applied Psychology*, 80, 468-478.
- [20] Conger, J. A., *Motivate performance through empowerment*. In E. A. Locke (ed.), The Blackwell Handbook of Principles of Organizational Behavior, pp. 137-149. Oxford: Blackwell Publishing, 1989.
- [21] Dierendonck, D. V., & Nijten, I., *The Servant Leadership Survey: Development and Validation of a Multidimensional Measure*. JOURNAL OF BUSINESS AND PSYCHOLOGY, Vol. 26, No. 3, pp. 249-267, 2010, DOI:10.1007/s10869-010-9194-1.
- [22] Dumdum, U. R., Lowe, K. B., & Avolio, B. J., A meta-analysis of transformational and transactional leadership. In B. J. Avolio & F. J. Yammarino (Eds.), *Transformational and charismatic leadership: The road ahead*, Oxford, UK, Elsevier Science, 2002.
- [23] George, J. M., *Emotions and Leadership: The role of emotional intelligence*. HUMAN RELATIONS, Vol. 53, pp. 1027-1055, 2000.
- [24] Green, M.T., *Graduate leadership*, Create Space and Leadership Studies, South Carolina, 2013.

- [25] Greenleaf, R. K., *The servant as leader*. In L. C. Spears (Ed.) Robert K. Greenleaf, Servant leadership: A journey into the nature of legitimate power and greatness, p.21- 61, Mahwah NJ, Paulist Press, 1970
- [26] Greenleaf, R. K., *The institution as servant*. In L. C. Spears (Ed.) Robert K. Greenleaf, Servant leadership: A journey into the nature of legitimate power and greatness, p.62-103, Mahwah NJ, Paulist Press, 1972.
- [27] Greenleaf, R. K., *Trustees as servants*. In L. C. Spears (Ed.) Robert K. Greenleaf, Servant leadership: A journey into the nature of legitimate power and greatness, p. 104- 146, Mahwah, NJ: Paulist Press, 1972.
- [28] Haibin, L., & Shanshi, L., *Effect of Situational Leadership and Employee Readiness Match on Organizational Citizenship Behavior in China*. SOCIAL BEHAVIOR & PERSONALITY: AN INTERNATIONAL JOURNAL, Vol. 42, No. 10, pp. 1725-1732, 2014.
- [29] Hater, J. J., & Bass, B. M., *Superiors' evaluations and subordinates' perceptions of transformational and transactional leadership*. JOURNAL OF APPLIED PSYCHOLOGY, Vol. 73, No. 4, pp. 695-702, 1988.
- [30] Hersey, P., Blanchard, K. H., & Johnson, D. E., *Management of Organizational Behavior: Utilizing Human Resources* (8th ed.), Prentice Hall, Englewood Cliffs, New Jersey, 2001.
- [31] Hinkin, T. R., & Schriesheim, C. A., *A theoretical and empirical examination of the transactional and non-leadership dimensions of the Multifactor Leadership Questionnaire (MLQ)*, THE LEADERSHIP QUARTERLY, Vol. 19, No. 5, pp. 501-513, 2008.
- [32] Johns, G., & Saks, A. M., *Organizational Behaviour: Under-standing and Managing Life at Work* (7th ed.), Prentice Hall, Canada, 2007.
- [33] Judge, T. A., Piccolo, R. F., & Ilies, R. (2004). The forgotten ones? The validity of consideration and initiating structure in leadership research. *Journal of Applied Psychology*, 89, 36-51.
- [34] Laub, J. A., *Assessing the servant organization: development of the Servant Organizational Leadership Assessment (SOLA) instrument*, Dissertation Abstracts International, 1999.
- [35] Liden, R. C., Wayne, S. J., Zhao, H., & Henderson, D., *Servant leadership: Development of a multidimensional measure and multi-level assessment*. THE LEADERSHIP QUARTERLY, Vol. 19, No. 2, pp. 161-177, 2008, DOI: 10.1016/j.lequa.2008.01.006.

- [36] Liden, R. C., Wayne, S. J., Meuser, J. D., Hu, J., Wu, J., & Liao, C. (2015). Servant leadership: Validation of a short form of the SL-28. *The Leadership Quarterly*, 26(2), 254-269. doi: 10.1016/j.lequa.2014.12.002
- [37] Lowe, K. B., Kroeck, K. G., & Sivasubramaniam, N. (1996). Effectiveness correlates of transformational and transactional leadership: A meta-analytic review of the MLQ literature. *Leadership Quarterly*, 7, 385-425.
- [38] Mathieu, C., Neumann, C., Babiak, P., & Hare, R. D. (2015). Corporate Psychopathy and the Full-Range Leadership Model. *Assessment*, 22(3), 267-278. doi:10.1177/1073191114545490.
- [39] Michel, J., Lyons, B., & Cho, J. (2011). Is the Full-Range Model of Leadership Really a Full-Range Model of Effective Leader Behavior? *Journal of Leadership & Organizational Studies*, 18(4), 493-507.
- [40] Morrison, E., *OB in AMJ: What is hot and what is not?* ACADEMY OF MANAGEMENT JOURNAL, Vol. 53, No. 5, pp. 932-936, 2010, <http://doi.org/dqrdfv5>.
- [41] Northouse, P., *Leadership: Theory and Practice*. Sage Publications, California, 2010.
- [42] Rafferty, A. E., & Griffin, M. A., *Dimensions of transformational leadership: Conceptual and empirical extensions*. THE LEADERSHIP QUARTERLY, Vol. 15, No. 3, pp. 329–354, 2004.
- [43] Seltzer, J., & Bass, B. M., Transformational leadership: Beyond initiation and structure. JOURNAL OF MANAGEMENT, Vol. 16, pp. 693–704, 1990.
- [44] Sendjaya, S., Sarros, J., & Santora, J., *Defining and measuring servant leadership behavior in organizations*. JOURNAL OF MANAGEMENT STUDIES, Vol. 45, No. 2, pp. 402–424, 2008.
- [45] Skogstad, A., Hetland, J., Glasø, L., & Einarsen, S. (2014). Is avoidant leadership a root cause of subordinate stress? Longitudinal relationships between laissez-faire leadership and role ambiguity, WORK & STRESS, Vol. 28, No. 4, pp. 323-341, 2014.
- [46] Spears, L. C., *Reflections on Leadership: How Robert K. Greenleaf's Theory of Servant-Leadership Influenced Today's Top Management Thinkers*, John Wiley, New York, NY, 1995.
- [47] Spears, L.C. (Ed.), *An Insights on Leadership: Service, Stewardship, Spirit and Servant-Leadership*, John Wiley & Sons, New York, NY, 1998.

- [48] Yammarino, F. J., & Bass, B. M., *Long-term Forecasting of Transformational Leadership and its Effects Among Naval Officers: Some Preliminary Findings*, Binghamton, NY, Center for Leadership Studies, 1988.



An Adaptive Time Step Scheme based on Taylor's Remainder Term

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ABSTRACT

An adaptive time step method was developed based on the Taylor series remainder term associated with Euler's method, which is utilized to solve initial value problems involving ordinary differential equations. The accuracy and stability of the developed method was determined for three test cases where one of the test cases was stiff. It is also show that the accuracy of the developed method compares well with Runge Kutta 2. In future research, this method will be applied to explicit and implicit versions of Runge Kutta 2 to include Calahan's method, which is a variation of the Rosenbrock's scheme.

Keywords: Runge Kutta; Adaptive Time Step; Error Control; Numerical Analysis

1. INTRODUCTION

The purpose of this paper is to present an adaptive time step method applied to Euler's schemes; this adaptive time step is based on the remainder term associated with the Taylor series representation of the RK scheme. Give the following initial value problem

$$\frac{dy}{dx} = f(x) \quad (1)$$

With $y(0) = y_0$

A possible numerical integration scheme is based on the idea that an RK method of order p has the following representation

$$y_{n+1} = y_n + \frac{y' h}{1!} + \frac{y'' h^2}{2!} + \cdots + \frac{y^p h^p}{p!} + R_p \quad (2)$$

Where R_p represents the remainder term and accounts for the terms truncated from the Taylor Series representation for y_{n+1} . The remainder term is also the local truncation error and represented as E_n with the following form

$$E_n = \frac{y^{p+1} h^{p+1}}{(p+1)!} \quad (3)$$

This work develops a method to estimate E_n and y^{p+1} and determine an adaptive time step, h_n , based on Equation 3. The developed h_n is then utilized within RK 1 (Euler's) scheme, which will be shown to be essentially as accurate as an RK-2 scheme.

The intent of this work is to lay a foundation for future research that will apply these ideas to a form of implicit RK scheme known as Calahan's method, which was expressly developed to address issues of stiffness. A stiff dynamic system is one where there are "fast" and "slow" dynamics as seen by eigenvalues that may differ by orders of magnitude [5].

Formally, stiffness can be defined as

$$S = \frac{\max |Re(\lambda_i)|}{\min |Re(\lambda_i)|} \quad (4)$$

Where the numerator is the value of the largest eigenvalue and the denominator is the value of the smallest eigenvalue. When S is greater than 100, the system is considered stiff [5].

Given in Figure 1, and as Equation 9, is a system that exhibits features of stiffness.

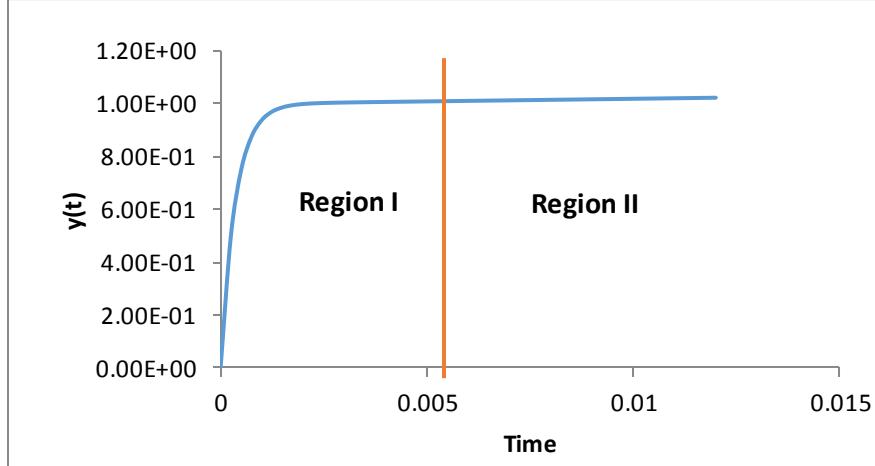


Fig. 1 Stiff Dynamic System

This figure has been divided into two regions given as Regions I and II. In Region I, and especially in the interval $t \in [0, .002]$, the slope of the tangent to the curve is very large and numerical integration schemes have difficulty integrating systems with large Jacobians, which introduce large errors unless a very small time step, h , is utilized.

For the proposed adaptive time step (see Figure 2), it can be seen that the $h(i)$ correctly addresses this issue. For Region I, $h(i)$ is small and for Region II, $h(i)$ is large.

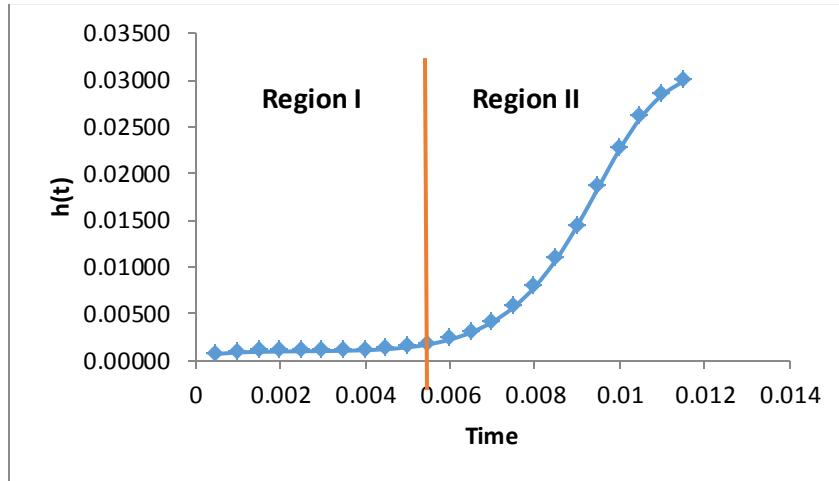


Fig. 2 Adaptive Time Step for System 1.

2 BACKGROUND

In Chapra and Canale [3], which presents a well-accepted method for adaptive time steps, the following sequence is utilized:

1. The local truncation error is estimated by two different methods (or results from a difference of using the same method with time steps of h and $h/2$)
2. The new step size is estimated as follows

$$h_{\text{new}} = h_{\text{present}} \left| \frac{\Delta_{\text{new}}}{\Delta_{\text{present}}} \right|^{\alpha} \quad (5)$$

Where h_{new} is the next step size, h_{present} is the current step size, Δ_{new} is the desired accuracy, and Δ_{present} is the current local truncation error. There are additional equations to determine Δ_{new} and a scale factor given as y_{scale} . Other resources in this area include [1, 2, 4, 5, 6].

There are essentially two main methods that utilize some form of the above procedure: 1) Runge Kutta Fehlberg and 2) Dormand-Price [7]. More often than not, the Dormand-Price scheme is utilized and is the basis to the Matlab® differential equation solver known as ODE45.

The main difference between these two schemes and what is proposed is the following. The two methods mentioned above insure a certain level of local truncation error at each iteration whereas the proposed methods do not explicitly insure this. As a trade-off in favor of the proposed method, Runge-Kutta-Fehlberg and Dormand-Price require much more computational effort and may not have a global error convergence comparable with the proposed method. These considerations are the subject of a future paper.

In this paper, a similar approach is utilized where the first step is the same, but the second step is based on the remainder term associated with the Taylor series representation for the Euler's scheme and is given as Equation 7.

3 METHOD

3.1 RK-1 Scheme

Euler's method or Runge Kutta 1 is given as

$$y_{n+1} = y_n + f(y_n)h \quad (6)$$

And the adaptive time step associated with this scheme, and determined from the remainder term, is

$$\phi h_n = \sqrt{\frac{2|E_n|}{\left|\frac{df_n}{dy_n}\right|}} \quad (7)$$

Where ϕ is a tuning factor and may depend on the type of dynamic system to be solved.

3.2 Estimating E_n

One means to estimate the local truncation error, E_n , is to determine y_{n+1} using time step h and then recalculate y_{n+1} using time step $h/2$. The difference between $y_{n+1}(h)$ and $y_{n+1}\left(\frac{h}{2}\right)$ is a measure of the local truncation error [2, 4].

In Figures 3, the local truncation error (actual) and local truncation error (estimated) compare favorably.

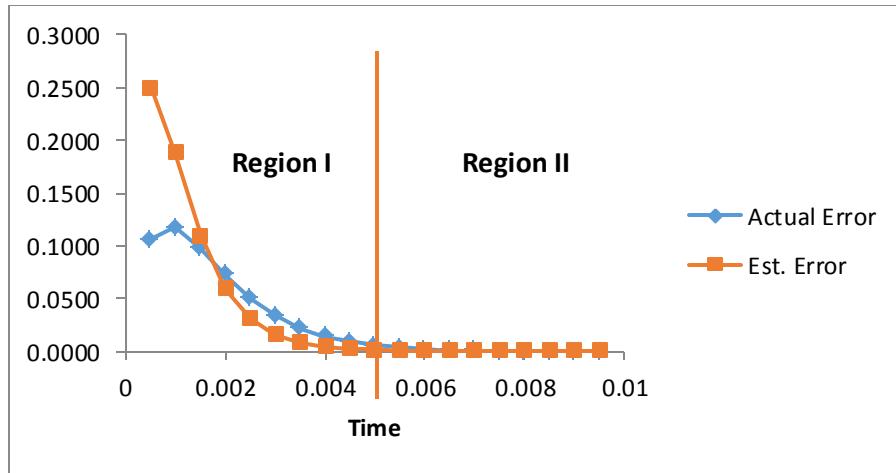


Fig. 3 E(i) versus Time for System 1

3.3 Estimating y^{p+1}

A central difference scheme was not utilized, but would improve the method, and is given as

1st Order

$$\frac{\Delta f}{\Delta t} = \frac{f(n+1) - f(n-1)}{2h} = \frac{f(n) - f(n-1)}{2h} \quad (8)$$

Instead, a forward difference was utilized. Equation 8 could be applied to the two iterations conducted at "h/2" to determine the local truncation error at each "n."

4 RESULTS

4.1 Dynamic Systems Considered

The three dynamics systems (Systems 1 to 3) considered below include one stiff system (System 1) and two non-stiff systems. For the systems where a solution is available (Systems 1 to 3), accuracy was determined for the four methods of numerical integration utilizing mean square error (MSE); see Table 1. The comparison was made for the half time step fixed step and adaptive step.

System	t(0)	t(f)	h(1), h(i)	ϕ	MSE
One, Adaptive	0	0.006	1.00E-06	1.618034	0.03
One, Fixed	0	0.006	3.00E-04	n/a	0.15
Two, Adaptive	0	.4	0.1	1.618034	0.002
Two, Fixed	0	2	0.1	n/a	0.43
Three, Adaptive	0	1	0.1	1.618034	0.1
Three, Fixed	0	2	0.1	n/a	2

*Both full step methods utilized 10 intervals for all systems.

Table 1 Parameter Conditions

4.2 Dynamic System I

$$\frac{dy}{dt} = -1000y + 3000 - 2000e^{-t} \quad (9)$$

With $y(0) = 0$ and analytic solution

$$y = 3 - .998e^{-1000t} - 2.002e^{-t} \quad (10)$$

Numerical solutions are given as Figures 4 and 5. From the mean square error given in Figures 4 and 5, it's easy to see that the adaptive time step method provides more accurate answers.

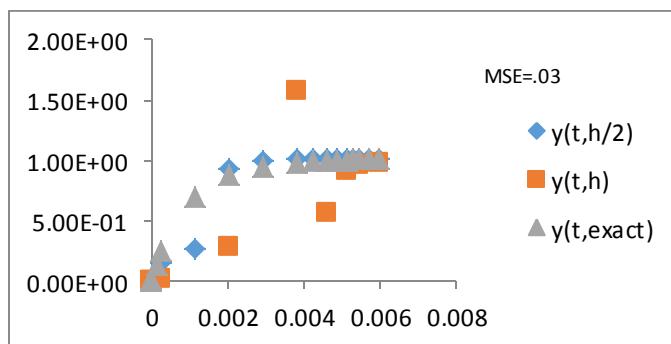


Fig. 4 Time vs. $y(t)$ for adaptive time step, System 1

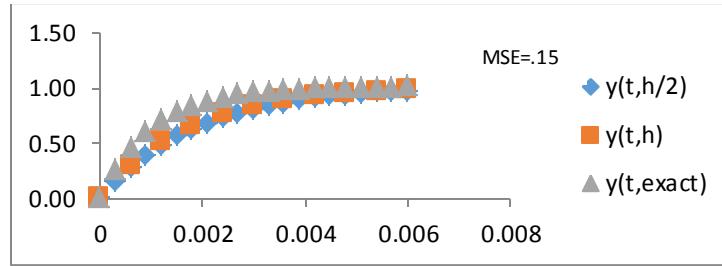


Fig. 5 Time vs. $y(t)$ for fixed time step, System 1

4.3 Dynamic System II

Integrate both analytically and numerically

$$\frac{dy}{dt} = \sin(t) \quad (11)$$

For $y(0)=0$ with analytic solution

$$y(t) = 1 - \cos(t) \quad (12)$$

Numerical solutions are given as Figures 6 and 7. Again from the mean square error given in Figures 6 and 7, it's easy to see that the adaptive time step methods provide more accurate answers.

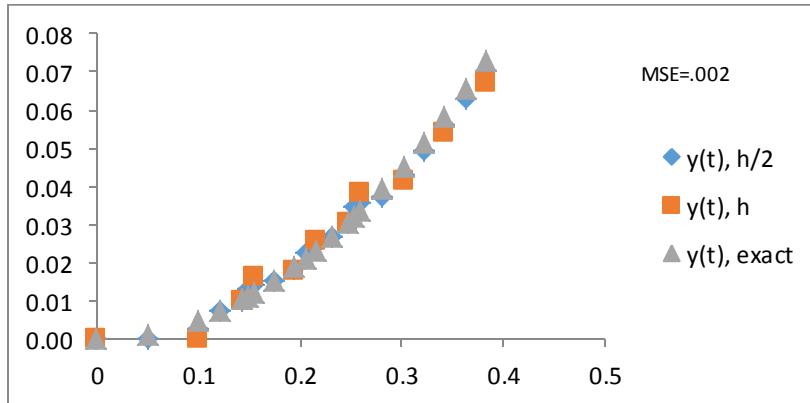


Fig. 6 Time vs. $y(t)$ adaptive time step, System 2

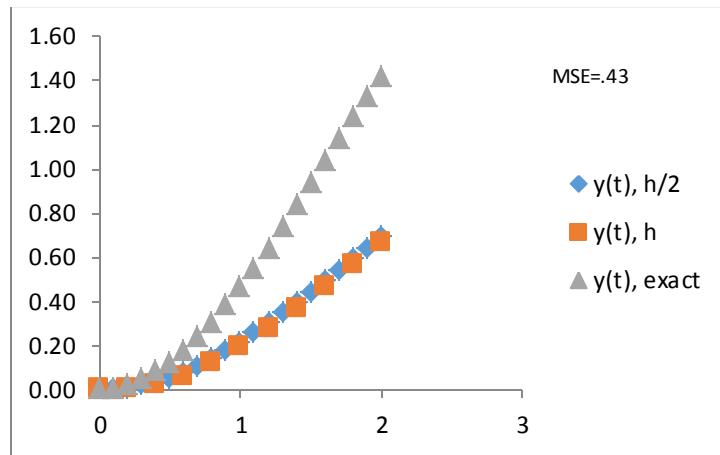


Fig. 7 Time vs. $y(t)$ fixed time step, System 2

4.4 Dynamic System III

Integrate both analytically and numerically

$$\frac{dy}{dt} = 10 - y(t), y(0) = 1; \quad (13)$$

With analytic solution

$$y(t) = y_0 e^{-t} + 10(1 - e^{-t}) \quad (14)$$

Numerical solutions are given as Figures 8 and 9. Further, the mean square error for the adaptive time step method is much better than the fixed time step method.

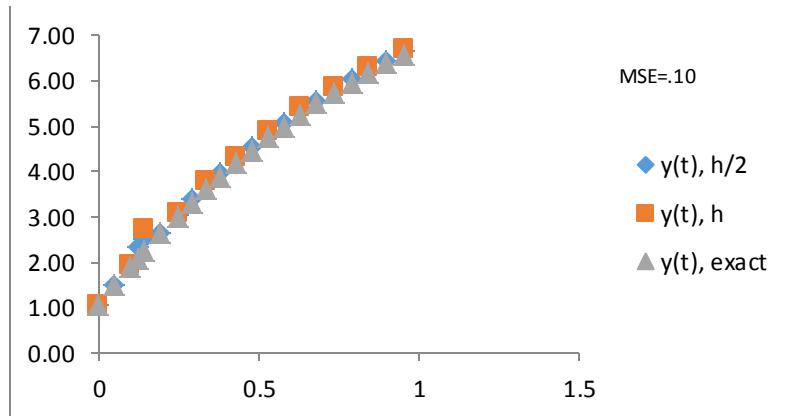


Fig. 8 Time vs. $y(t)$, adaptive time step, System 3

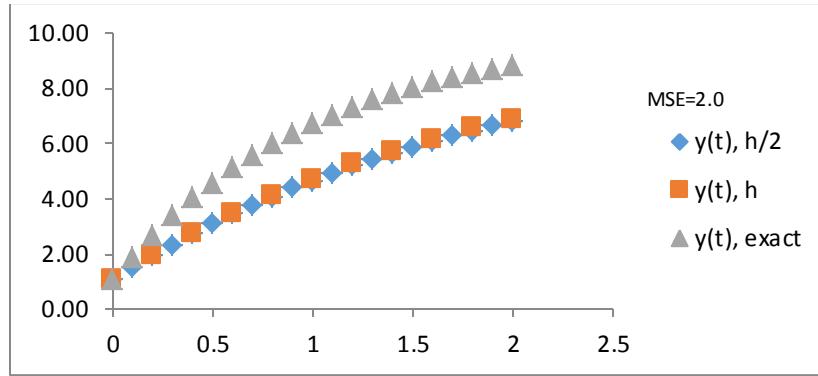


Fig. 9 Time vs. $y(t)$, fixed time step, System 3

4.5 Comparison with RK-2

It is natural to wonder if adding in the Taylor remainder term associated with a Euler's scheme is essentially a RK-2 method. As seen in Figures 10 and 11 for Systems 1 and 3, the accuracy of the Adaptive Euler's scheme and RK-2 are comparable. Additionally, the MSE associated with each pair in Figures 10 and 11 are comparable.

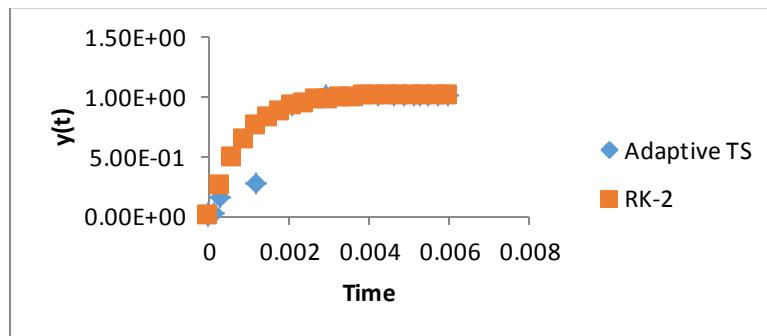


Fig. 10 Comparison between Adaptive Time Step Scheme and RK-2 for System I

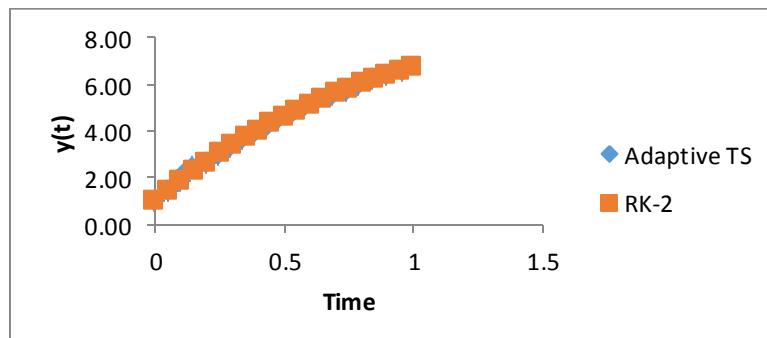


Fig. 11 Comparison between Adaptive Time Step Scheme and RK-2 for System III

5 DISCUSSION/CONCLUSIONS

An adaptive time step method was developed for Euler's scheme and is based on the remainder term associated with a Taylor series representation. The developed scheme was

compared against a fixed time step Euler's scheme for three dynamics systems to include one that is stiff and showed higher accuracy. In fact, the accuracy of the developed method is comparable with RK-2 (see Figures 10 and 11). It is noted that the method's accuracy and numerical stability is dependent on the tuning factor and initial step sized used.

Future work will look at applying the developed scheme to RK-2, RK-4 and an implicit RK method known as Calahan's method. Additionally, the effects of initial step size and tuning factor on accuracy and stability of the scheme will be explored as well as looking at global error convergence when compared against other adaptive step schemes and computational effort.

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REFERENCES

- [1] Aiken and Lapidus (1974). AIChE Journal, 20, pp. 368.
- [2] J.C. Butcher (2008). Numerical Methods for Ordinary Differential Equations; John Wiley and Sons, New York, NY.
- [3] Chapra and Canale (2010). Numerical Methods for Engineers; McGraw-Hill, Boston, MA.
- [4] C.W. Gear (1971). Numerical Initial Value Problems in Ordinary Differential Equations; Prentice-Hall.
- [5] Prokopakis and Selder (1981). "Adaptive Semi-Implicit Runge Kutta Method for Solution of Stiff Ordinary Differential Equations"; Ind. Eng. Chem. Fundam., 20, pp. 255 to 266.
- [6] Seinfeld, Lapidus, and Hwang (1970). "Review of Numerical Integration Techniques for Stiff Ordinary Differential Equations"; Ind. Eng. Chem. Fundam., 9, 2, pp. 266 to 275.
- [7] Golberg, Oleg (2007). Accessed from
<https://dspace.mit.edu/bitstream/handle/1721.1/55903/18-034Spring-2007/NR/rdonlyres/Mathematics/18-034Spring-2007/Projects/euler.pdf> on 10/4/2016.

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