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Highlights

- Building a Framework for ICT
- Development of Method and Tool
- Particle Swarm Optimization
- Family Communication Strategy

Discovering Thoughts, Inventing Future

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University Students' use of Whatsapp and their Perceptions Regarding its Possible Integration into their Education

By Al-Mothana M. Gasaymeh
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Keywords: whatsapp, university students, educational purposes, jordan, arab world, developing country, social networking sites.

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Al-Mothana M. Gasaymeh

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Keywords: whatsapp, university students, educational purposes, jordan, arab world, developing country, social networking sites.

I. Study Background

Social Networking Sites (SNSs) are very popular among university students. The use of different types of SNSs is common among university students in different parts of the world. For instance, Bsharah, Gasaymeh, and Abdelrahman (2014) found that 92.6% of 282 university students who participated in a study in a university in Jordan reported using Facebook. Hamade (2013) found that 89% of 300 students who participated in a study in a university in Kuwait reported using Twitter. In a large-scale study, Karpinski, Kirschner, Ozer, Mellott, and Ochwo (2013) found that 100% of 875 students from universities in the United States and in Europe reported using different types of SNSs. Students commonly use their smartphones to access their SNSs (Vorderer, Krömer & Schneider, 2016). This enables them to use SNSs anytime and anywhere. SNS have been used for variety of purposes including communication, exchanging media, and entertainment (Raza, Qazi & Umer, 2017; Eid & Al-Jabri, 2016). SNSs are easy, cheap, convenient, reliable, entertaining, and they can be accessed anywhere (Krishnan & Hunt, 2015; Nam, students in the Arab world have used SNSs to overcome 2015; Billedo, Kerkhof, & Finkenauer, 2015; Al-Jabri, Sohail, & Ndubisi, 2015). Furthermore, university the social norms and cultural constraints that are present in gender segregated societies.

The popularity of SNSs among university students might suggest that they would be suitable and valuable tools which could be used for educational purposes. SNSs have been used to: facilitate online and blended education; provide easy and flexible access to educational materials; provide students with administrative information; facilitate communication among students and between students and instructors; replace learning management systems; and motivate students (Schroeder & Greenbowe, 2009; Wang, Woo, Quek, Yang, & Liu, 2011; Pollara, & Zhu, 2011; Meishar-Tal, Kurtz, & Pieterse, 2012; Callaghan & Bower, 2012; Irwin, Ball, Desbrow, & Leveritt 201). The use of SNSs has great potential in higher education in developing countries because of their availability and affordability.

Their use does not require expensive digital tools such as laptop computers. Students own and know how to use the necessary software (i.e., SNS applications) and hardware (i.e., smartphones).

One type of SNS that might have potential in higher education to support teaching and learning is WhatsApp Messenger. WhatsApp Messenger is a popular SNS in different parts of the world. Statistics have shown that there were 1.2 billion active monthly users of WhatsApp in 2017 (Statista, 2017). WhatsApp Messenger is a smartphone- and web-based instant message application that allows users to exchange information using a variety of media including text, image, video, and audio messages (Church & de Oliveira, 2013; Sahu, 2014). WhatsApp is a free, easy to use, fast, convenient, personal mode of communication.

It is easy to form groups with WhatsApp or to use it for private communication (Tang & Hew, 2017). It can be used to communicate anywhere and at any time, and it is commonly used by university students worldwide (Bere, 2012; Yeboah & Ewur, 2014). WhatsApp is used in different fields, such as health services (Wani, Rabah, AlFadil, Dewanjee, & Najmi, 2013); marketing (Priyono, 2016), tourism (Štefko & Mudrík, 2016), and business (Priyono, 2016). Devi and Tevera (2014) found that WhatsApp was one of the most popular SNSs among university students. Ahad and Lim

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(2014) found that WhatsApp is popular among undergraduate students, and that they they use it on a daily basis. Ahad and Lim reported that students attributed their heavy use of WhatsApp to its ease of use, speed, real-time messaging, and low cost.

WhatsApp can be used in higher education in a number of ways to achieve different educational goals. For instance, Gachago, Strydom, Hanekom, Simons, and Walters (2015) argued that WhatsApp can be used in higher education to create immediate connections, encourage reflection, and facilitate coordination in informal and formal learning. Chipunza (2013) found that WhatsApp was a useful electronic tool to facilitate information sharing among university students on a range of subjects related to the courses that they were studying. The author reported that "WhatsApp served as a tool for bridging access to learning resources, rendering peer-based and hierarchical support, leveraging on-task behavior and enhancing meaningful context-free learning" (p. 336). Tarighat and Khodabakhsh (2016) found that WhatsApp can be useful in language assessment. Students can use WhatsApp to record their speech and share their recordings with their teachers and other students. Alsaleem (2013) examined the effect of the use of WhatsApp on English as Foreign Language (EFL) students in written vocabulary tasks in Saudi Arabia. The author found that WhatsApp had a positive effect on students' performances. The students enjoyed using WhatsApp as a learning tool. They perceived the use of WhatsApp as a game rather than a formal class requirement. Ngaleka and Uys (2013) reported that WhatsApp can be used to facilitate mobile learning. In their study the students used WhatsApp as a communication tool outside the classroom to exchange information about meetings and projects. Barhoumi (2015) found that the use of WhatsApp to facilitate blended learning had a positive and significant impact on students' learning performance and their attitudes toward blended learning. Bansal and Joshi (2014) examined college of education students' experiences of WhatsApp mobile learning and found that the use of WhatsApp increased students' social interactivity with each other and with the instructor, and this facilitated collaborative learning. In addition, the authors found that students had positive attitudes toward the use of WhatsApp in their leaning. Bere (2013) found that WhatsApp could be useful to "create alternative dialogic spaces for student collaborative engagements in informal contexts, which can gainfully transform teaching and learning" (p. 544). Tang and Hew (2017) reported that WhatsApp had been used in different academic disciplines to support students' learning.

These academic disciplines included education, mathematics, information systems, and languages.

The educational advantages of WhatsApp, students' positive attitudes towards its use, and its popularity suggest that WhatsApp has significant potential for use in higher education. In developing countries, university students have limited access to expensive technologies such as desktop and laptop computers. The use of WhatsApp in education does not require special infrastructure. University students own the hardware (i.e., smartphones) and they can download the software (i.e., the WhatsApp application) for free. WhatsApp can be used for teaching and learning to bridge the digital divide among students.

Some research studies have examined university students' use of WhatsApp. Yeboah and Ewur (2014) examined higher education students' use of WhatsApp. Four hundred and eighteen students completed a questionnaire. The results showed that most were heavy users of WhatsApp. More than 96% of the participants reported using it for more than three hours a day. Most participants used WhatsApp for chatting while only 7% reported using it for academic work.

Students' perceptions of the use of WhatsApp in their educational processes have been examined in some studies. For instance, Malecela (2016) examined students' perceptions of the use of WhatsApp as a learning tool in a university in Malaysia. A qualitative research design was followed in which interviews were conducted with some students. The results showed that the students believed that WhatsApp could be helpful in their learning by facilitating: communication with other students and with the instructor, collaborative learning, and access to and sharing of educational information. WhatsApp can be used as a medium for learning and teaching the English language. However, the students in Malecela's (2016) study believed that the use of WhatsApp as a learning tool had the following limitations: it did not involve face-to-face communication, it was time consuming, there was a risk of miscommunication, it was constrained by the rules of phone etiquette, it was dependent on Wi-Fi connections, and it could not be used by individuals who had their phones on silent mode.

In Hong Kong, So (2016) found that university students who had experience with the formal use of WhatsApp to support their learning, and those who had no experience with the use of WhatsApp for learning, had positive perceptions of its use to support teaching and learning in higher education. The students agreed that WhatsApp can be a useful learning tool. Examples of reported possible advantages of the use of WhatsApp for students' learning included: providing immediate messaging support, bringing new opportunities of learning, facilitating communication between students and teachers, enabling fast feedback in learning, providing flexible learning, supporting multimedia learning, and supporting collaborative learning. However, the participants said that the use of WhatsApp in their learning might interfere with their private lives

Smartphones and their apps can be beneficial for disadvantaged universities and for countries that suffer from limited budgets and a shortage of computer labs. WhatsApp is a commonly available, popular, and affordable electronic tool. It has been integrated into university students' learning in different ways to accomplish diverse educational tasks. It provides several educational advantages for university students.

In Jordan, the use of smartphones and SNSs is popular among university students. However, the availability and affordability of such technologies do not necessarily mean their integration into students' learning will be successful. Therefore, the current study examined the use of WhatsApp, one of these popular technologies. It investigated university students' use of WhatsApp and their perceptions regarding its possible integration into their education

II. Purpose Of The Study

The aim of this study was twofold: 1) to investigate first year university students' use of WhatsApp for personal and educational purposes and 2) to examine their perceptions of the formal integration of WhatsApp in their education.

The research questions of the current study were:

Research Question 1: What is the extent of students' use of WhatsApp for personal purposes?

Research Question 2: What is the extent of students' use of WhatsApp for educational purposes?

Research Question 3: What are the perceptions of students regarding the formal integration of WhatsApp in their education?

III. Research Methods

A quantitative research method was used in this study. Data were collected using a questionnaire instrument to measure university students' use of, and perceptions of, the formal integration of WhatsApp in their education.

a) Participants

The participants were a group of students from a university in Jordan. They were all enrolled in one class. Table 1 shows the demographic characteristics of the participants.

Table 1: Descriptive Summary of Participants' Demographic data

	Category	Frequency	Percentage
Gender	Male	72	46.8
	Female	82	53.2
Age	18-20	150	97.4
	21-25	4	2.6
Major	Education	4	2.6
	Arts and Literature	37	24
	Science	50	32.5
	Engineering and Computer Science	35	22.7
	Nursing and Health Science	22	14.3
	Business Management	6	3.9

One hundred and fifty-four students completed the questionnaire. The numbers of female students and male students were approximately equal. Most participants were under the age of 20, and the class in which the participants were enrolled was offered to first- and second-year students. The participants were from a range of academic disciplines.

b) Instruments

The data collection tool was a paper-based questionnaire. The questionnaire consisted of four sections that were designed to collect the following data: 1) demographic characteristics; 2) students' use of WhatsApp for personal purposes; 3) students' use of WhatsApp for educational purposes; and 4) students' perceptions of the formal use of WhatsApp for educational purposes. The options for responses in the 'use' sections (i.e. sections 2 and 3) were: daily, weekly, monthly, and never. The options for responses in the perceptions section (i.e. section 4) were: strongly disagree, disagree, undecided, agree, and strongly agree. The questions were based on the researcher's observations and previous research studies (e.g., Roblyer, McDaniel, Webb, Herman, & Witty, 2010; Abu-Alruz, 2014; Al-Emran, Elsherif, & Shaalan, 2016; So, 2016).

c) Procedure

A class that was available to all students in the university was randomly selected for the study. The class was offered as an elective unit, and students from two streams of the class participated in the study. The instructor and the students agreed to participate. The researcher visited the two streams and made a presentation about the aim of the study and the use of WhatsApp in students' formal learning. During the same visits, questionnaires were completed by the students and collected by the researcher.

d) Data Analysis

Frequency distributions were used to represent participants' demographic data, and to answer the first and second research questions regarding participants' use of WhatsApp for personal and educational purposes. Descriptive statistics, in the form of means and standard deviations, were used to answer the third research question regarding students' perceptions of the formal integration of WhatsApp in their education.

IV. Results And Discussion

a) WhatsApp Use for Personal Purposes

All the participants reported using WhatsApp in their personal and social lives. Table 2 shows the types of personal and social activities that the students used WhatsApp for, based to the frequency of use (daily, weekly, monthly and never). Most of the participants reported using WhatsApp for staying connected with fiends, parents, and relatives on a daily basis. In addition, most of the participants used WhatsApp daily to share pictures and videos. Most participants used WhatsApp groups to exchange information. Using WhatsApp to share music files and personal information with others was less common. The findings in relation to the popularity of WhatsApp among university students align with the findings of similar studies (Yeboah & Ewur, 2014; Ahad & Lim 2014; Devi & Tevera, 2014).

University students use their smartphones to access WhatsApp. Smartphones are popular among university students (Tahat, Al-Dabesi, & Al-Qta, 2014; Dahlstrom & Bichsel, 2014). Unlike other technologies, the use of smartphones does not require special equipment or infrastructure. The students had the necessary hardware and software in their hands constantly. The smartphone is a personal technology that users carry with them wherever they go and at all times. The popularity of WhatsApp among university students can be attributed to the technological affordability of such technology. WhatsApp is commonly available, free, and easy to use. Furthermore, the popularity of WhatsApp is related to the popularity of the traditional Short Message Service (SMS). SMS is a popular communication tool among university students (Gasaymeh & Aldalalah, 2013; Gasaymeh & Qablan, 2013; Balakrishnan & Loo, 2012; Tahat et al. 2014; Ahad & Lim, 2014). Students use SMS in their social and personal lives because it is fast, convenient, readily available, immediate, straight to the point, and private (Bouhlel, Mzoughi, Hadiji, & Slimane, 2011; Balakrishnan & Loo, 2012; Oluga & Babalola, 2013).

They use it to contact friends; exchange information, congratulations and jokes; for banking; and to receive news (Tahat et al. 2014). However, the use of traditional SMS has some limitations and shortcomings. For instance, text is the only type of data that can be exchanged via SMS, and there are limitations to the number of characters that can be sent in one SMS message. Therefore, the users of SMS usually use abbreviations (such as "2" for "to" and "AFAIK" for "as far as I know"), and many users find them confusing (Leung, 2007) WhatsApp has the same communication capabilities as SMS but has some more advanced features and technical characteristics. Different types of data (text, audio, video, Microsoft office files, and location-based messages) can be exchanged using WhatsApp. Users of WhatsApp can find out whether people on their contact list are available, typing messages, or offline. In addition, users of WhatsApp can know whether a sent message has been received and read. In addition, electronic groups can be formed using WhatsApp. Therefore, WhatsApp can provide users with the feeling of being part of a group. Cost might be another factor that encourages smartphone users to use WhatsApp. WhatsApp allows users to exchange information free of charge using their internet data plans. Church and de Oliveira (2013) summarized some motives for WhatsApp adoption. These included: low cost, social influences, technical characteristics, sense of connection and community, immediacy, and reliability,

Table 2: Frequency Distributions of Participants' Responses to WhatsApp Use for Personal Purposes.

		Daily	Weekly	Monthly	Never
I use WhatsApp to					
1.	… share music files with others	59(38.3%)	34(22.1%)	26(16.9%)	27(17.5)
2.	… share pictures with others	101(65.6%)	28(18.2%)	16(10.4%)	9(5.8%)
3.	… share videos with others	82(53.2%)	40(26%)	17(11%)	12(7.8%)
4.	… keep in touch with friends	113(73.4%)	21(13.6%)	8(5.2%)	9(5.8%)
5.	… keep in touch with parents	106(68.8%)	23(14.9%)	7(4.5%)	16(10.4%)
6.	… keep in touch with relatives	76(49.4%)	36(23.4%)	15(9.7%)	24(15.6%)
7.	… to chat with specific electronic groups	78(50.6%)	32(20.8%)	11(7.1%)	30(19.5%)
8.	… keep others informed of what's going on in my life	60(39%)	36(23.4%)	12(7.8%)	39(25.3%)

b) WhatsApp Use for Educational Purposes

Table 3 shows the types of educational activities that the students used WhatsApp for. Students' use of WhatsApp for educational purposes was less common than their use of WhatsApp for personal and social purposes. The finding in relation to the limited use of WhatsApp for educational purposes among university students aligned with similar research studies (e.g., Yeboah & Ewur, 2014). The most common use of WhatsApp for educational purposes was to facilitate communication among students. Such use is similar to their use of WhatsApp for personal and social purposes.

The use of WhatsApp for communication between students and instructors was not common; the majority of the students did not use WhatsApp to communicate with instructors or to build relationship with instructors. However, about a quarter of the participants reported that they used WhatsApp daily to: publish course announcements, discuss ideas about courses with classmates, seek help from the students who had already taken courses, post links to topics and resources related to courses, form groups for study purposes, organize meetings with classmates, and organize times to study.

The findings showed that a limited number of students used WhatsApp for educational purposes, and that these students used WhatsApp for informal learning activities. A possible explanation of the low use of WhatsApp for educational purposes is that the students responded to the course requirements, and WhatsApp was not formally integrated into their learning. It is likely that students' use of technology for educational purposes was affected by the use of technology by faculty members. In addition, the students might have been unaware of how to use WhatsApp to support their learning

Table 3: Frequency Distributions of Participants' Responses to WhatsApp Use for Educational Purposes.

		Daily	Weekly	Monthly	Never
I use WhatsApp to					
1.	… communicate with my classmates about matters related to courses requirements	61(39.6%)	35(22.7%)	28(18.2%)	28(18.2%)
2.	… communicate with my instructor about matters related to courses requirements	16(10.4%)	30(19.5%)	30(19.5%)	74(48.1%)
3.	… publish courses announcements	35(22.7%)	29(18.8%)	25(16.2%)	64(41.6%)
4.	… to discuss ideas about courses with my classmates	37(24%)	34(22.1%)	30(19.5%)	42(27.3%)
5.	… discuss ideas related to courses with instructors	25(%16.2)	27(%17.5)	32(20.8%)	64(41.6%)
6.	… seek help related to the course requirements of students who have already taken the courses	36(23.4%)	42(27.3%)	27(17.5%)	44(28.6%)
7.	… post links to topics and resources related to courses	41(26.6%)	25(16.2%)	40(26%)	46(29.9%)
8.	… to form student groups for educational purposes	36(23.4%)	23(14.9%)	37(24%)	54(35.1%)
9.	… organize meetings with my classmates regarding the assignment and projects required by the instructors	38(24.7%)	35(22.7%)	28(18.2%)	48(31.2%)
10.	… communicate with instructors about office hours and meetings	24(15.6%)	25(16.2%)	25(16.2%)	79(51.3%)
11.	… build good relationships with the instructors	25(16.2%)	20(13%)	25(16.2%)	81(52.6%)
12.	… to get feedback from course instructors	33(21.4%)	26(16.9%)	32(20.8%)	59(38.3%)
13.	… organize my time to study	40(26%)	26(16.9%)	19(12.3%)	69(44.8%)

Table 4 shows that the participants' perceptions of the formal use of WhatsApp to support their learning ranged between "undecided" and "agree" (M =3.44, SD =.77). Participants responded most positively to the item that stated "I think it would be easy to use WhatsApp in my education" (M=3.66, SD=1.11), and least positively to the negatively worded item that stated "I think using WhatsApp in education will cause me social problems" (M=3.03, SD=1.17). The results indicate that students believed using WhatsApp in their education would be: easy, fun, and useful. The students had positive intentions regarding the use of WhatsApp in their education if it were to become an option. The students' responses suggest that they would accept the use of WhatsApp in their learning. However, the students were not sure about the effect of the use of WhatsApp for educational purposes on their social lives. Arab culture is characterized by collectivism rather than individualism (Ameen & Willis, 2015), which means that individual behavior is influenced by the surrounding gender segregated society. Using SNSs, including

WhatsApp, is one way for students in Arab cultures to seek freedom from cultural and social restrictions.

Using WhatsApp to send or receive messages, or to form groups, does not require a complex set-up process (Tang & Hew, 2017). The findings of this study showed that the use of WhatsApp to support students' learning does not require adaptation and intensive training for students, and this would make it easy for WhatsApp to be integrated into their learning. The finding regarding students' positive perceptions of WhatsApp's ease of use in their learning aligned with the findings of other studies (e.g., Ahad & Lim, 2014).

Students believed that the use of WhatsApp to support their learning would be fun. This belief was based on their use of WhatssApp in their personal and social lives. Most university students enjoyed using WhatsApp to socialize with people and exchange different forms of data. Their positive perceptions would make it easier to integrate WhatsApp into their learning. Students' enjoyment of the use of a technology is an important factor in the success of its adoption (Davis, Bagozzi, & Warshaw, 1992). The finding regarding students' positive perceptions of the enjoyment of the use WhatsApp's in their learning aligned with the findings of other studies (e.g., Alsaleem, 2013).

The students believed that the use WhatsApp to support their leaning would be useful for their learning. Students' intense use of WhatsApp for personal and social purposes reflected the benefits of WhatsApp in their daily lives. Therefore, the students anticipated that the formal use of WhatsApp in their learning would be helpful. Students' use of WhatsApp for personal and social purposes, and their perceptions that it was easy, fun, and useful, meant they had positive attitudes towards the use WhatsApp in their formal learning. The students liked the idea of using WhatsApp in their formal learning and they said they would use it if it became available. The finding regarding students' positive perceptions of the use of WhatsApp in their education aligned with the findings of similar studies. For instance, So (2016) found that university students who had no experience with WhatsApp for learning had positive perceptions of its use to support teaching and learning in higher education.

Table 4: Descriptive statistics of participants' responses to their perceptions of the formal integration of WhatsApp in their education

		M	SD
1.	I think it would be easy to use WhatsApp in my education	3.66	1.11
2.	I would not feel scared and hesitant when using the WhatsApp in my learning	3.60	1.20
3.	I think using WhatsApp in my education would be fun	3.54	1.14
4.	If face technical problems using WhatsApp I can solve them in one way or another	3.49	1.10
5.	I would like to use the WhatsApp in the educational process	3.43	1.31
6.	I think the use of WhatsApp in my education would be helpful	3.34	1.02
7.	*I think using WhatsApp in education will cause me social problems	3.03	1.17
	Overall	3.44	.77

**Negatively stated item*

V. Conclusions and Recommendations

Previous research has shown that WhatsApp has several technological, social, and pedagogical advantages.Theses studies have shown that WhatsApp is popular among university students and that students use it constantly for different purposes in different parts of the world. These advantages and WhatsApp's popularity suggest that it could be used to support students' formal learning, particularly in developing countries that might have economic and infrastructure constraints. The current study found that participants have access to smartphones and WhatsApp. Students use WhatsApp for personal and social purposes on a daily basis. However, among the participants the use of WhatsApp for educational purposes was limited. Students used WhatsApp in their education in ways that were similar to its use for personal and social purposes.

For instance, the most common use of WhatsApp for educational purposes among the participants was to communicate with each other on matters related to their education.

Students' limited use of WhatsApp for educational purposes can be attributed to the lack of formal integration of WhatsApp in their learning, and their lack of knowledge and skills on how to use WhatsApp to support their learning. However, the participants had positive perceptions of the formal use of WhatsApp to support their learning. They believed the integration of WhatsApp into their education would be easy, fun, and useful. They had positive feelings and intentions regarding the possible use of WhatsApp in their formal learning. However, the participants were not sure about the social acceptance of the use of WhatsApp in their education. The use of WhatsApp to overcome some social norms in conservative Arab societies that limit communication between female and male students might not be socially supported. Students in Arab cultures look for liberation from cultural and

male students might not be socially supported. Students in Arab cultures look for liberation from cultural and social restrictions through the use of SNSs such as WhatsApp.

Jordanian students were already users of smartphones and WhatsApp. They had positive perceptions of the use of WhatsApp to support their learning. The use of WhatsApp in higher education does not require costly infrastructure for the students or their universities, as the students have the required software and hardware in their hands all the time. The availability of software and hardware is a significant consideration in emerging countries, in which higher education institutions have difficulty providing students with expensive ICT that might be used to support their learning. Students' ways of using WhatsApp for personal and social purposes would inform the ways in which the technology is integrated into their education. The findings of this study suggest that the use of the WhatsApp would enable students to access learning and educational material outside of lectures, and it would facilitate communication between students, and between students and their instructors, and it would facilitate collaborative learning through the formation of electronic groups. The formal integration of WhatsApp into university students' learning requires considering the students' social constraints and privacy.

Further studies are required to improve understanding in relation to the use of WhatsApp in university students' learning. The findings of the current study have shown that the use of WhatsApp in students' learning in Jordanian universities would be accepted by the students. However, future research should address students' perceptions of and attitudes towards specific uses of WhatsApp in their learning. In addition, there is a need to for empirical studies that examine the effect of the use of WhatsApp on students' learning performance and motivation.

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Building a Framework for ICT Project Implementation and Evaluation

By Abdullah AL-Malaise AL-Ghamdi
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Abstract- In this technological era with a wide range of Information and Communication Technologies(ICT) resources, organizations are dealing with massive amounts of data, highly equipped infrastructure, and a sustainable business environment and are attempting to obtain competitive advantages while securing their capital in an aggressive market environment. The use of technology offers a chance for firms to produce better quality products and services, in addition to creating a productive work environment and encouraging all types of stakeholders to take more interest in organizational business activities. The evaluation of this massive investment with the proper framework is a real challenge for almost every organization. This paper discusses the different approaches used for evaluating ICT projects, such as pre- and post- implementation evaluations through the measurement of financial and non-financial returns. This study proposes a framework to overcome the main issues related to ICT project implementation and evaluation. The details about possible phases and steps further enhance the reader's understanding of the use and implementation of the frameworkin any industry.

Keywords: ICT evaluation, pre-assessment, postassessment, ICT project's returns, ICT evaluation framework.

GJCST-G Classification: D.3.3

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Building a Framework for ICT Project Implementation and Evaluation

Abdullah AL-Malaise AL-Ghamdi

Abstract- In this technological era with a wide range of Information and Communication Technologies(ICT) resources, organizations are dealing with massive amounts of data, highly equipped infrastructure, and a sustainable business environment and are attempting to obtain competitive advantages while securing their capital in an aggressive market environment. The use of technology offers a chance for firms to produce better quality products and services, in addition to creating a productive work environment and encouraging all types of stakeholders to take more interest in organizational business activities. The evaluation of this massive investment with the proper framework is a real challenge for almost every organization. This paper discusses the different approaches used for evaluating ICT projects, such as pre- and post- implementation evaluations through the measurement of financial and non-financial returns. This study proposes a framework to overcome the main issues related to ICT project implementation and evaluation. The details about possible phases and steps further enhance the reader's understanding of the use and implementation of the frameworkin any industry. The study has implications both for researchers working in this field and for ICT decision makers from any industry to improve their decision-making processes for new projects using pre- and post-implementation evaluations with the help of the proposed framework.

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I. Introduction

Currently, ICT projects are serious motivators for organizations to perform well in the competitive environment and contribute to society in ways that make their customers and employees satisfied with the provided services. Keeping this in mind, companies are investing substantial amounts to create competitive advantages and improve firm performance. According to the statistics presented in the Gartner report, organizations' spending on ICT resources is expected to reach $3.5 trillion globally during the year 2017(Gartner 2016). In addition, this report has categorized the ICT investment into five major categories, in increasing order of amount spent: (i) data center systems, (ii) software, (iii) devices, (iv) IT services and (v) communication services. Data center systems ($173 billion) and communication services ($1.384 trillion) are the smallest and largest investments, respectively.

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This study focuses on the issues that organizations are facing in the prediction and measurement of the impact of this massive amount of investment. The measurement approach may require the organization to determine whether an ICT project has successfully achieved its objectives or failed and to justify this determination. ICT projects are not always successful; there are several reports that discuss the failure rates of ICT projects due to many reasons. As(Al-Shehab, Hughes, and Winstanley 2005)explained, 51% of project failures are due to time constraints and non fulfillment of the desired functionality that was predicted before the project implementation. One of the major reasons for ICT project failure is the organization not having or following a proper evaluation process (Nawi, Rahman, and Ibrahim 2011; Farrukh Saleem et al. 2013). Inability to identify the potential impact on the organization, planning errors, underutilization of resources and projects that do not provide the functionality for the purpose that they have been implemented are some of the common reasons for ICT project failure. The aim of this study is to overcome the issues in identifying the potential impact of ICT projects on an organization based on the investment objectives. Moreover, this study attempts to build a comprehensive framework that can help ICT decision makers predict and measure the possible returns from ICT investment.

II. Related Work

There are many kinds of ICT projects, such as integration of multiple applications into one portal (AL-Ghamdi and Saleem 2014), implementation of automated decision-support systems (F. Saleem and AL-Malaise AL-Ghamdi 2012), development of business architecture (Al-ghamdi and Saleem 2016), making the system scalable to improve efficiency(Altalhi et al. 2016), enterprise resource planning (Ullah et al. 2013), and customer-relationship management (Al-Mudimigh, Saleem, and Ullah 2009).To assess the impacts of ICT projects, researchers have proposed several approaches based on different criteria. The multi-dimensional impact of ICT resources on organizational objectives (Maçada and Beltrame 2012) and the advanced application of ICT resources (Greenspun et al. 2016; Lovelock et al. 2015) make the evaluation more complex (Dadayan 2006). Dadayan further explained that the complexities involved in evaluating ICT projects are mainly due to (i) the number of processes involved

in achieving business objectives and (ii) the current business situation (Dadayan 2006). In addition, improper methodologies for measuring ICT projects and inadequate identification of project objectives are some other reasons that make this process more complex (Farrukh Saleem et al. 2013). This highlights the research gap and requirements of a framework that can guide an organization in keeping track of ICT investments and making full use of the resources to prevent underutilization.

The evaluation approaches help the organization understand stakeholder participation and motivation to improve the ICT decision-making process using different methods. The findings of this section have implications for the characterization of the measurement factors that can be used in the framework for measuring ICT projects. Moreover, the major factors involved in the evaluation process and the findings of some common evaluation approachesare briefly discussedin a literature review and in the context of the proposed framework.

This section elaborates the list of categories based on the different characteristics mentioned above, as shown in Figure 1. At the top level, the techniques categorized as pre- and post-implementation evaluation, which highlights the time period for measuring the investment(Cress well, Burke, and Pardo 2006). The purpose of pre-evaluation methods is to analyze the potential future impact of ICT investment within a specific period of time based on cost and other related features(AGIMO 2004). The pre-evaluation methods further help to analyze the investment before implementation. Another way of measuring ICT investment is known as post-evaluation, which helps to evaluate the list of attained objectives and output for the investment (Olsen et al. 2005). Based on the previous discussion in section 1, it is evident that each organization has different kinds of objectives for ICT investment. This study has further organized the literature to associate each objective with a possible list of output value returns. For measuring an ICT project's value returns, this section covers different previously proposed methodologies based on multiple factors, from objective to subjective(Wilson and Howcroft 2005), such as cost-benefit analysis(Dadayan 2006)and the measurement of other strategic and informational benefits achieved by ICT projects (Shang and Seddon 2002). To narrow the focus while proposing the framework for measuring ICT projects, the subsequent section discusses how to recognize the different kinds of evaluations, their objectives, and the procedure for predicting and measuring the results of ICT projects.

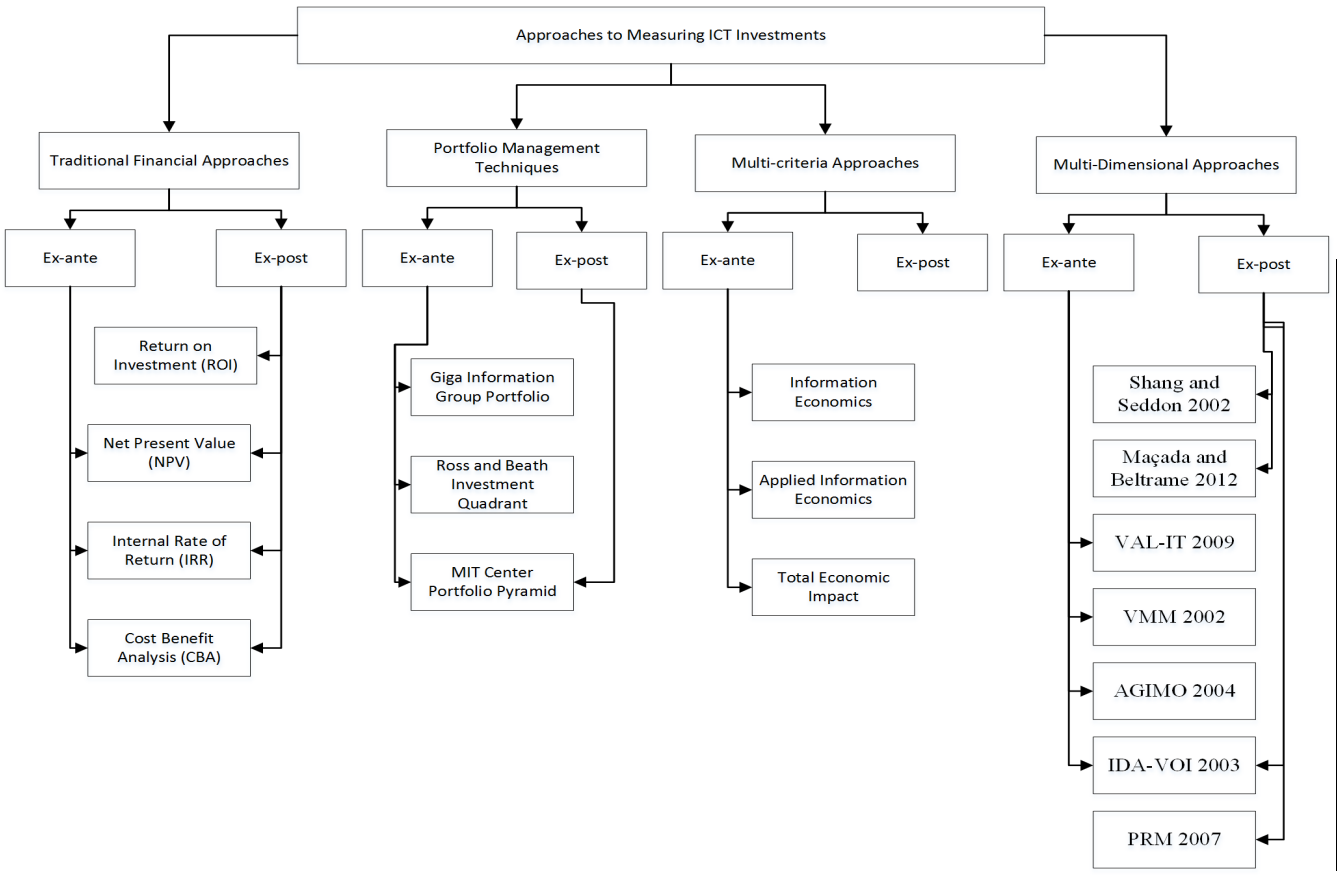

Figure 1: Approaches to measuring the results of an ICTproject. Adapted from (Farrukh Saleem et al. 2016)

III. Discussion Of Framework

The flowchart of the proposed framework, shown in Figure 2, illustrates the measurement ofan ICT project from multiple perspectives. Organizations are keen to update IT infrastructure and software capabilities to support the business process and other activities. This study describes how an organization can keep track of and analyze ICT projects before and after implementation. The framework represents an integrated approach that combines possible techniques extracted from the literature review. ICT project portfolio-management techniques, pre- and post-implementation financial analyses, and post-implementation financial and non-financial measurement techniques are some common methods that are incorporated in the proposed framework. The framework is useful for ICT decision makers and business organizations, as it can provide the performance measurements and assess the ICT project comprehensively. The framework is divided into three phases, as discussed below.

a) Phase 1 – Pre-Assessment

Pre-assessment is normally performed during the planning phase. Every ICT project requires proper planning based on the requirements and objectives of the project. The basic purpose of pre-assessment is to finalize the list of functionalities for which the ICT project is implemented. Using preliminary analysis and a list of outcomes outlined for the ICT project (AGIMO 2004) is one of the methods designed by the Information Management Office of the Australian government. VMM, which was proposed by (VMM 2002),is another method that provides prospective analysis based on cost, value and risk analyses in defining the IT project. Another set of approaches that an organization can use, which are known as IT portfolio-management techniques, provide comprehensive analysis before project implementation. Total Economic Impact(Gliedman 2003) and Information Economics (Parker and Benson 1989) are the most famous IT portfolio methods used for building cases for ICT projects. Risk analysis, the possible outcomes, and the list of expected benefits are some of criteria on which the pre-analysis is based. On the other hand, researchers have proposed different methods based purely on financial analysis. Net present value (NPV 2016)and Cost-Benefit Analysis (CBA 2016) are the methods used in pre-analysis to predict possible financial return from an ICT project. Based on the findings of the literature review, the following processes has been identified and can be used for pre-assessment in phase1:

Objectives, scope, outcomes, when/who applies(AGIMO 2004)

Potential benefits analysis in terms of money, time and quality (IDA-VOI 2003)

Prediction of the impact on business values(Gliedman 2003)

Cost-benefit analysis, value linking, value-acceleration analysis(Parker and Benson 1989)

Net benefit analysis (NPV 2016)

Cost-benefit analysis (CBA 2016).

b) Phase 2 – ICT Project Implementation

In this phase, the organization needs to finalize the different aspects, such as project implementation and use factors. At this stage, ICT decision makers discuss the current nature of the problem to justify the purpose and implementation of the ICT project. The ICT project's objectives need to be identified properly in this phase. The list of objectives defined at this stage will further help to measure the impact of the ICT project on the organization according to the directions given in Phase 3of the framework. The implementation process is critical; implementation of ICT resources in a justified place, proper utilization of ICT resources, ICT adoption and use are the main issues that must be investigated in this phase. The ICT project manager and his team are key players during the implementation phase. They strive to understand the user's requirements, to face the praise or criticism from stakeholders and, finally, to address every challenge adequately. Moreover, change management is a classical problem that the project manager must address smartly. The following are the some of the major factors that need to be considered during implementation phase, as discussed in different ICT project-implementation methodologies:

Determine the project objectives and the output variable to compute after implementation(Parker and Benson 1989);

Beneficiary and stakeholder analysis(IDA-VOI 2003):

Benefits structuring (IDA-VOI 2003):

Strategy→ Value → Architecture → Delivery questions(VAL-IT 2009)

c) Phase 3 – Post-Assessment

The final phase of the proposed framework is the ICT project's post-implementation assessment based on multiple perspectives. Several organizations have developed methodologies for measuring the post-implementation impact of ICT projects. Researchers have categorized the post-assessment approaches into two categories: financial and non-financial. Traditionally, financial return, which is also known as Return on Investment (ROI) (ROI 2016), is the most common approach that an ICT decision maker uses for measuring the financial return from any investment. Robert Enterprise enhanced the idea of ROI with Social ROI (SROI) (SROI 2001). The SROI approach was designed to measure the environmental, social and public economic impacts of a project on the organization, in addition to the financial returns. The idea

of measuring Value on Investment (VOI) presented by Gartner (Harris, Grey, and Roz well 2001) was a step to change the measurement criteria from financial to non-financial. VOI is the approach used for assessing the non-financial impact of any investment on the organization. Furthermore, different factors have been proposed for measuring the non-financial impact of an ICT project on the organizational business values. "Strategic," "Informational" and "IT Infrastructure" are the factors that were used in the context of a Brazilian firm to build a framework for the measurement of an ICT project's impact on business values (Maçada and Beltrame 2012). Shang and Seddon (Shang and Seddon 2002) presented the framework that can help to measure the benefits created by enterprise systems in Australian firms using "Operational." "Organizational," "Managerial" and "Transactional" factors. In addition, "Transformational" factors were proposed by (Gregor et al. 2006) to assess the values achieved by an organization after the implementation of an ICT project.

Several other researchers have proposed post-implementation assessment frameworks and discussed the issue of ICT projects(Gregor et al. 2006; F. Saleem et al. 2012; Farrukh Saleem et al. 2013, 2015, 2016). The following are some factors based on findings from a literature review that can help an organization to measure the post-implementation impact of an ICT project:

Return on investment (ROI 2016);

Value on investment (Harris, Grey, and Rozwell 2001);

Social return on investment (SROI 2001);

Non-financial benefits (Dadayan 2006);

Strategic, Information and IT infrastructure benefits (Maçada and Beltrame 2012);

Operational, Organizational, Managerial, and Transactional benefits (Shang and Seddon 2002);

Transformational benefits (Gregor et al. 2006).

The above discussion of the proposed framework highlights the importance of using different methodologies for the implementation and measurement of an ICT project. The research gap highlighted in this study is that the pre- and post-implementation evaluations of ICT investment are still subject to ongoing debate. Some frameworks cannot handle important intangible factors, while some only measure financial returns. The integrated approach used in this framework can help the organization measure the ICT project from financial and non-financial perspectives using pre- and post-implementation assessment phases.

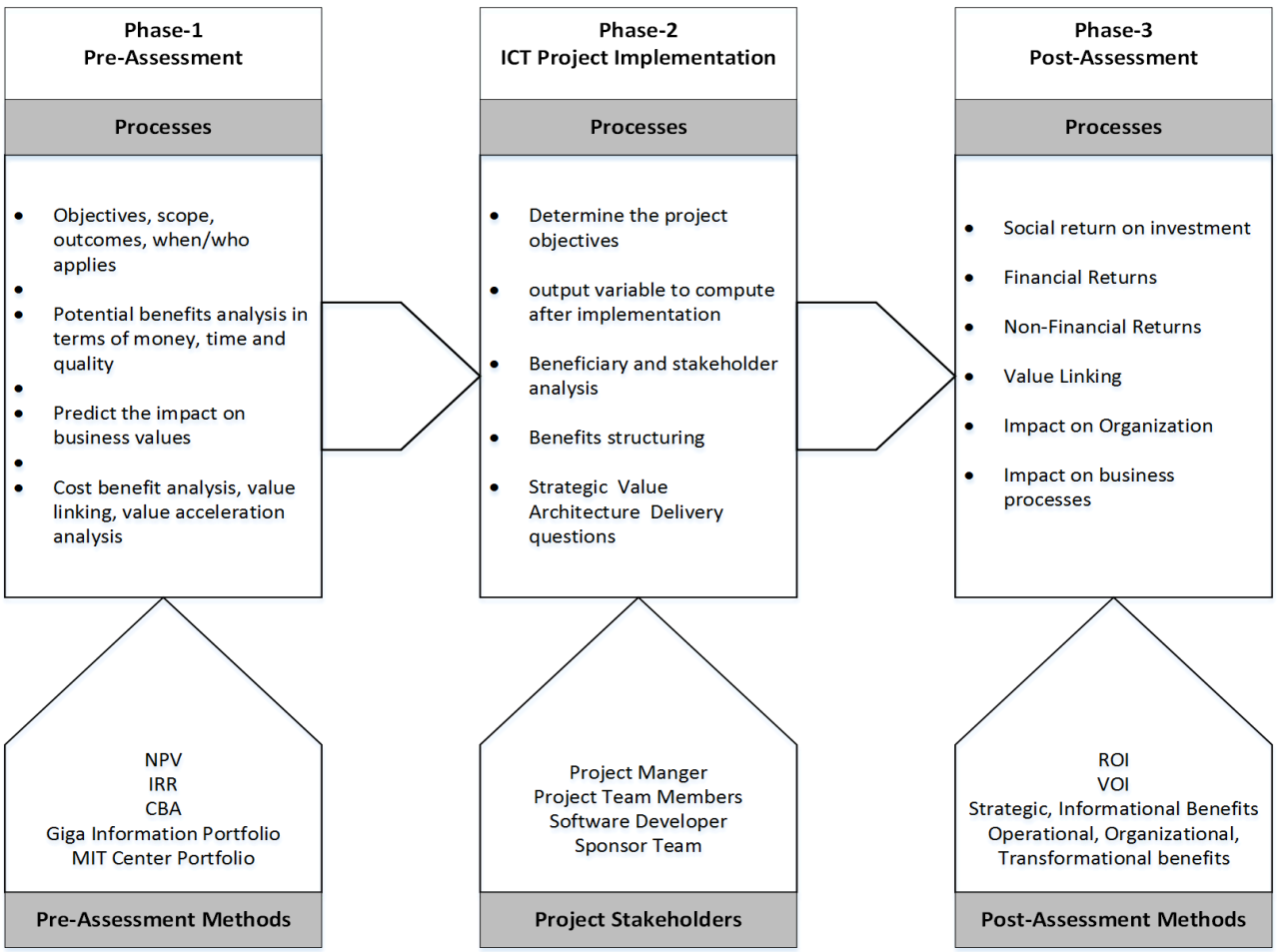

Figure 2: Proposed Framework for ICT Project Implementation and Evaluation

IV. Conclusion

The aim of this study was to investigate several points related to ICT project implementation and assessment. Determining an ICT project's influence on organizational performance is important, as this will help firms better evaluate their ICT projects and large investments. This paper incorporates previous research to create the basic framework and highlight the implications of the findings and deliverables of this study. Using this framework, a researcher can determine whether an organization is making ICT investments to achieve their business objectives in effective ways. ICT resources can help the organization to achieve their business objectives. Consequently, the results of any ICT investment/project can be predicted during pre-assessment and actual returns can be evaluated during the post-implementation phase based on the project's objectives. Therefore, the analysis conducted based on previous work helped to determine the specific processes and methods to use during the pre-assessment, project-implementation and post-assessment phases, as discussed in the proposed framework. This proposed work will allow the organization to easily measure the results of an implemented ICT project if its objectives have been identified correctly during the pre-assessment period. The implementation of the framework in an organization is proposed as future work to demonstrate the applicability of the method discussed in this study.

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Development of Method and Tool for Optimizing the Earthwork with Ex-Situ Remediation of Polluted Soil

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Abstract- In this article a method is developed for optimizing the work share between dozers and excavators in the excavation work of polluted soil. Experiences are implemented in order to both validate hypothesis and set relations between measurable physical parameters (like the overlay between lines or the maximal line length) and excavation efficiency. In the final part of the article, the author shows how work share between machines can be optimized by using calculations on the appropriate parameters in a calculation sheet and parameterizing a solver tool.

Keywords: *remediation work optimization, pollution clean-up optimization, moves optimization, industrial disaster, ex-situ remediation, heavy equipment, bulldozer, excavator, precision remediation.*

GJCST-G Classification: *B.4.0*

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I. Introduction

Whether it is with industrial remediation or with disaster remediation; remediation is always a challenge because of both the quite high technical requirements and implementation costs (Zithong, 2012). The development proposed in this article aims at sustaining some innovative ideas in the field of soil remediation with the implementation of precision remediation techniques in order to both reduce implementation costs and achieve remediation objectives more precisely. Our belief is that information technology could greatly improve the efficiency of the processes. In a previous study the author demonstrated the feasibility of precise remediation planning with the help of GIS technology and specifically designed geo-processing tools; and also demonstrated that precise planning spares earthwork (Lucas, 2015, Lucas 2016). Nevertheless one parameter was voluntarily omitted (the percentage of overlay between passages), another was chosen arbitrary[1] (the maximal line length). This study - which considers the field applications- targets these operational parameters and analyses how they affect efficiency.

Ex-situ remediation is exclusively targeted. Ex-situ remediation objectives are much different than those of classical excavation earthwork. Traditional earthwork considers volumes and their moves in a dig, fill and excavate approach. The approach is purely quantitative. Ex-situ remediation has to deal additionally with qualitative aspect: contaminated soil should be excavated whereas none contaminated should remain to the extent of possible untouched; also cross contamination should be avoided. In the case the remediation objective is 100% (so no pollution should be left on site) the planning and the field practices should avoid to leave pollution on site. As a consequence excavation practices should be adapted or even changed.

This study is organised in five parts. Part one sets the frame of the study with definitions, key concepts, objectives and hypothesis. The second part is a state of the art regarding optimization and efficiency in earthwork. The production line is analysed segment by segment and the latest developments with optimization are introduced. This part helps us to situate our developments inside the research landscape within the earthwork efficiency topic. Part three aims at testing and validating the hypothesis with the help of modelling. In part four a calibration method is proposed. Two parameters are controlled while experimenting with a model: the percentage of overlay (as an entry parameter) and maximal push length (measured). Then calibration curves are built. Finally a calculation tool is developed in the last part. It calculates optimized key parameters using the calibration results. Several set of parameters are used to test diverse scenarios with the scope to identify leverage parameters and refine the approach.

II. Important Concepts, Starting Points and Orientations

The problems dealt in this study are very specific and complex. We set some adapted terminology for their description. Additionally we made some decision regarding starting points and orientations. For the sake of clarity we would like to provide the reader with all the necessary information before to start with the development of research work.

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[1] The reason is these parameters were not relevant for the algorithm development, they make sense when considering the field approach and heavy equipment efficiency consideration.

a) Objectives

Efficiency is twofold in the frame of this study. First by order of importance is the technical efficiency, which means efficient achievement of the remediation objectives (the precise excavation of polluted soil). Secondly efficiency is also measured economically through the operation costs so as a higher efficiency would be less costly. Unless it is specified, the efficiency will refer to the technical efficiency. Our objectives follow the same hierarchy. First we consider the best technical achievements, and secondly will see how costs vary with the technical choices[2]. This choice is caused by the remediation process which at first is led by technical requirement: an objective for pollution removal. (ADEME 2006).

The remediation objectives are usually defined in a remediation plan. In particular the maximum amount of pollution that can remains after remediation work is accomplished. It can be 0% if all the pollution should be removed. It can be more if a certain amount of pollution can be left on site. In the frame of this study we decided to be able to cover diverse pollution removal objectives for several reasons. A 100% removal objective because we believe that technology should be used towards the best achievement[3]. The second reason is if dissimilarities happen between theory and practice, the practical achievement should still have high level. And lower removal objectives in order to offer a solution for less demanding remediation.

b) Machines combination

Table 1: Summarize the characteristics of the diverse equipment.

Machine type	Bull dozer	Wheel tractor/loader	Motor grader	Wheel tractor-scrapper
Overview				
Configuration	blade before tracks	blade before wheels	wheels before blade	wheels before blade
Collect efficiency	low (go/return and turn)	low (go/return and turn)	Medium (full line)	High (full line)
Robustness	Very high but can be stiff	High and flexible	limited to good condition	limited to good condition

Table 1 summary of the advantage and disadvantage of the three options.

Presently and after analysis of literature (CATERPILLAR, 2016; Nehaoua, 2013) we see three possible combination of equipment for performing the work, then we have made our own development regarding spacial coverage and work organisation in the field.

The first uses first dozers with parallel go, return and turn moves to make earth dump at the end of lines (fig.1a) and the cooperation with excavators to remove the earth dump and open the way for further work of the dozer (fig.1b). Because of the go and return moves it is not the less costly, nor the fastest approach, but it is applicable in any case as the robust equipment can perform work in any terrain conditions.

In the second motor grader equipment could replace the dozers. In that case the go, return and turn can be spared as the grading equipment can dump the contaminated soil in one passage in perpendicular direction compared to the moves of the former proposal (fig. 1c). In order to spare moves with the excavator the dump can be grouped every two passages. Then the excavator excavates the contaminated soil in the same way as with the first approach (fig. 1d).

[2] Our presumption is that technological support will help to increase work efficiency, avoid redo and expenses will dicrease proportionally.

[3] This does not mean that 100% will be acheived in the field. Field acheivevement can only be know with field tests.

The third use a tractor-scrapper and directly excavate the contaminated soil (fig. 1e). [4]

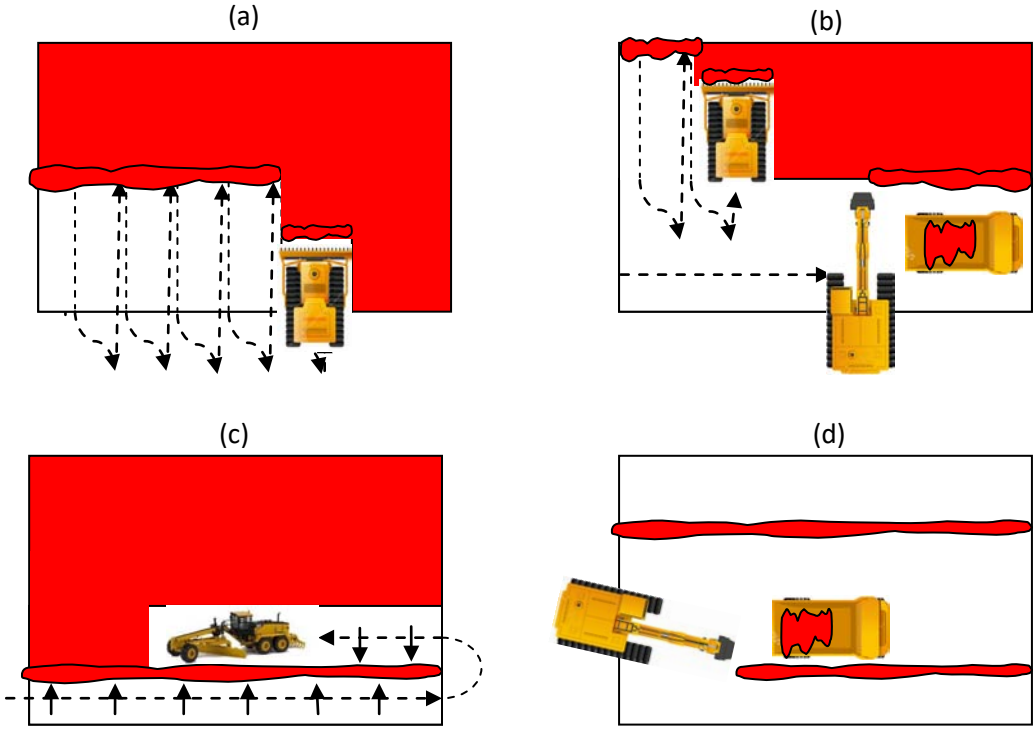

Fig.1: 3 possible cooperation approaches

The decision making for remediation method is a complex process where methods efficiencies, achievements and costs are compared (ADEME 2006, Colombano 2010). Depending on the situation (type of pollution, constraints) a method can be relevant in one case and not relevant in the other. This is the reason why the three options are considered and 3 different scenarios are proposed.

Among the criteria that can favour a method or another we can mention:

1. The consistency of the soil. If a soil has rock or heterogenic elements scrapper and grading equipment could be weak in these conditions (SETRA & LCPC, 2000).
2. Priority to time. In the case priority is given on time rather than on high level remediation objectives, it is profitable to use a fast approach (with a tractor-scrapper for example).
3. Accuracy objective. Some equipment (grading machine, scrapper) have front wheels before their grading equipment (fig. 2). Such configuration can bury pollution on sensitive soil. Moreover the front well can move pollution from contaminated area to clean (or cleaned) areas. If for example soil is sensitive to compression and remediation objectives are strict it would not be a good decision to use those equipments.

[4] the enforceability of different heavy equipment with the detailed analysis and the machine controll will be the subject of a specific publication

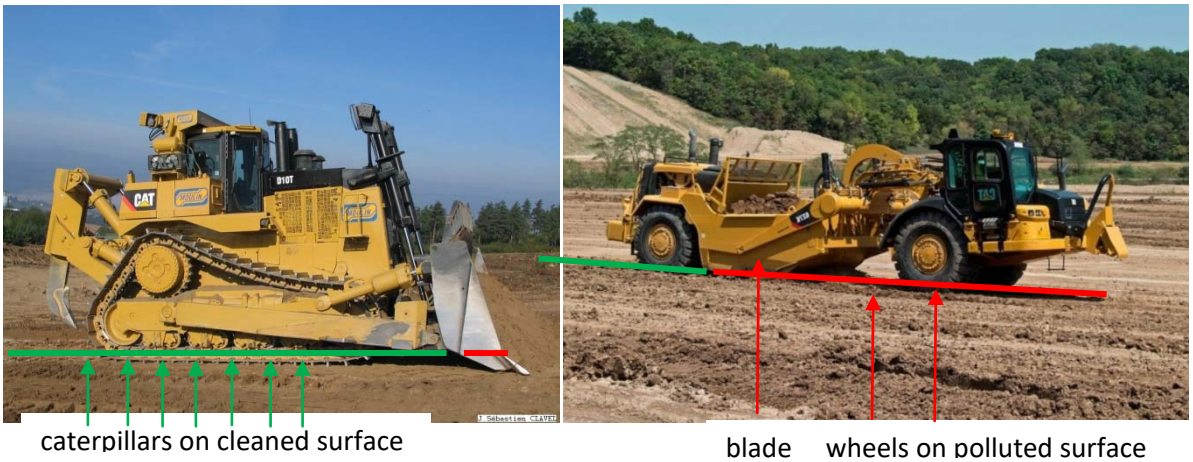

Fig.2: Comparison of configuration between a bulldozer and a tractor-scraper machinery

4. Sometime (in emergency situations for example) the technical solution depends mainly on the equipment immediately available.

c) *Details on the operations using dozer in the field*

While dozer performs work and material get accumulated in the blade some material is ejected on the sides of the blade. We called it "side dump" (fig. 3).

Figure 3: Side dump happening on the side of blade.

Side dump happens when the storage capacity of the equipment is reached after a certain distance was run. We call this distance "maximum line length" and note it l_{max} (fig. 4).

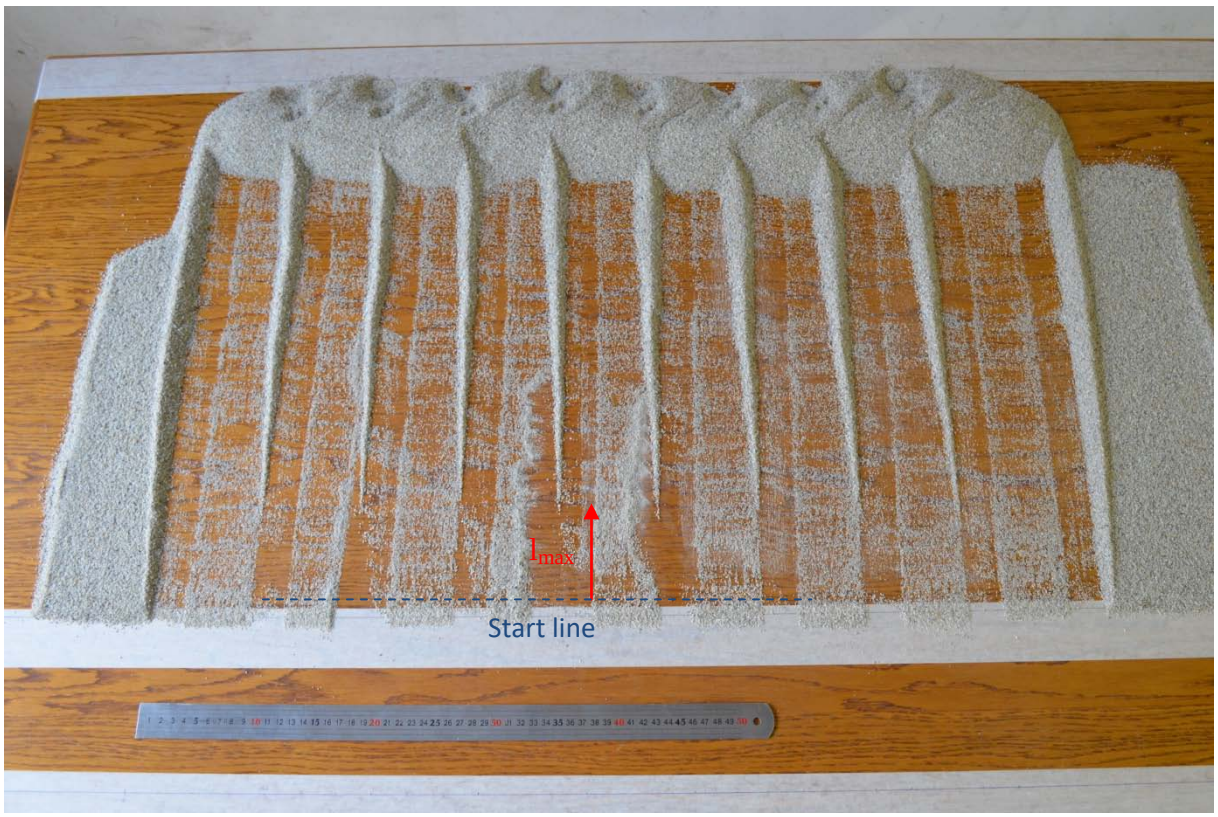

Figure 4: Maximum line length

The line length (noted l) is the length a dozer has gone from start point (time 0) to time t.

When side dump effect is not overcome polluted soil remains on site. To overcome side dump effect, the planning and the realisation have to integrate an overlay between the passages. Overlay is the percentage of lateral overlay between the two footprints of two blade passages (fig. 5). We express the overlay value as a percentage of the blade width.

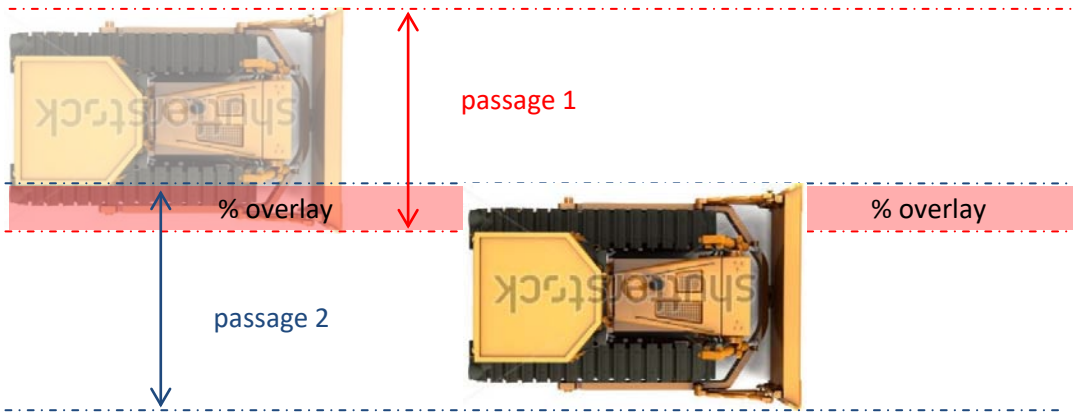

Figure 5: Percentage of overlay representation

If line length increases over l_{max} then the overlay is not annihilating any more the side dump effect and polluted soil is left. The solution to increase l_{max} is increasing the overlay.

d) Key parameters and their interactions

The percentage of overlay and l_{max} are two key parameters which are supposed to affect the efficiency of the remediation process. The threads below illustrate how complex the situation is and how the interactions work.

As we mentioned above, if longer lines are used in the planning, the overlay should be increased to compensate a more important side dump all along the lines. This has several consequences on efficiency:

1. more overlay means more lines per unit of area for the dozer, i.e. less efficiency for moving the same volume of soil.
2. more side dump means waste of energy, because dozer power is used to move contaminated soil on the side (which is not wished), instead of moving it at the end of the line, resulting in an inefficient use of dozer power.
3. longer lines means less dump lines per unit or area, means less route for the excavator, means lower expenses. So with the parameters varying in the same direction we have opposite effect on the efficiency of dozer and excavator use.

From this short analysis we see the complexity of the problem. Those threads are developed by logic and reflection. Experiments will bring concrete element of reflection and qualitative information to confirm the hypothesis made and to support the method development.

e) Hypothesis

1. Shorter lines are more efficient. Planning should favour shorter line pattern.

f) Postulate

2. The go, return and turn practice with bulldozer is the most secure to ensure remediation in any condition.

III. State of the Art Regarding Earthwork Efficiency Optimization

No reference matching narrowly our field of research could be found. Nevertheless a broader research targeting earthwork optimization brought some information of interest.

First we should mention the general method and indications for performance measurement developed in the CATERPILLAR performance handbook 46 (CATERPILLAR, 2016). Few sentences give a good summary of the general idea. “Machine performance must ultimately be measured in unit cost of material moved, a measure that includes both production and costs. Factors bearing directly on productivity include such things as weight to horsepower ratio, capacity, type of transmission, speeds and operating costs.” and “There are other less direct machine performance factors for which no tables, charts or graphs are possible”. We will keep these indications in mind while we will develop the optimization tool and make decision on parameters.

Also optimization of earthworks efficiency has been focused on: (1) equipment allocation for achieving the maximum earthmoving productivity (Cheng, 2010, Cheng 2005, Marzouk 2002, Moselhi 2007, Hess, Conesa-Muñoz 2016, Parente 2014, Shi 1999, Hola 2010); (2) excavator productivity (Halbach 2016, Edwards 2000, Tam 2002); (3) hauling improvement (Chaojue, 2016, Xu 2011) ; (4) least cost for cut and fill operations (Nassar 2012); (5) several tasks optimization (Kataria, 2005) ; and (6) integrated, multi methods and multi objectives optimization of earthwork (Parente, 2016, Zhang, 2008, Marzouk 2004,).

Recently Parente conducted an extensive review and research work on the global optimization of earthwork (Parente et al., 2016). Parente noticed that effective and practical integrated solutions have not been established so far. Solutions exist only for single tasks or partial processes that comprise earthwork (i.e. compaction cycle optimization, excavation cycle improvement). Parente considers earthwork is a complex mechanism where sequentiality and interdependency are noteworthy; and conventional operations research method (linear computing (Murphy. 2005)) is not effective enough for solving global site optimization issues. To this respect he used a couple of technologies like evolutionary computation, data mining (i.e., soft computing), geographic information systems and linear programming in order to achieve the optimization goals. Parente mentions the quality of an earthwork project design depends on the ability to estimate the associated equipment productivity (Parente et al., 2016). For this reason he use evolutionary computation and data mining to first provide realistic estimates of the productivity of available resources and secondly to perform their optimal allocation throughout the construction site (Parente et al., 2016). He employs GIS and linear programming for supporting the optimization of resource and material management, as well as of the trajectories associated with transportation of material from excavation to embankment fronts.

We would like to situate our research work in the light of the information gleaned so far. Similarly to Parente we plan to use a couple of techniques/technologies to efficiently tackle a complex problem where sequentiality and interdependency are noteworthy. The spatial efficiency is resolved using geo-processing and GIS technology (Lucas G., 2016). Efficiency approach through data mining is impossible as no data exists about remediation earthwork. Instead efficiency models for the equipment can be established by calibration approach that can be easily applied in the field. Last, the elementary collaboration issues between equipment can be resolved with linear computing. In the case numerous heavy equipments would be mobilized and work organized on several front, additional optimization with evolutionary computation would be necessary. The frame of this study aims at prefiguring the work organisation at elementary level, linear computing seems sufficient at the moment to tackle the interdependency issues foreseen with the equipment in the remediation work.

Making researches about artificial intelligence and planning of machine automation, we could find several alternatives with the planning. An option is realizing the planning beforehand; it then exposes the plan exploitation to risks and problems because of unforeseen events and different terrain reality. A second option is dynamic planning and real time planning (Barto, 1995, Wang, 2016, Saska 2008, Hess, Halbach 2016, Andrew 1995). They offer more flexibility and immediate correction in the field. This second approach requires an excellent experience about the hazards and problems happening in the fieldwork. As we are paving the way with this topic, we are in a too early stage to consider real time approach. We rather should control precisely x,y and z dimensions and coverage and decided to make a global plan beforehand.

IV. Test of Hypohesis 1: the Increase of Line Lengh Decrease the Collect Efficiency

a) Aims and objectives

This experiment aims at understanding and examining the mechanics of the carriage process.

A first objective is assessing the "reliability" of the carriage. Our objective is to realize a series of measurements in order to be able to evaluate the variance. Our belief is as follow: if variance is low this means the carriage phenomena is reliable (stable and regular); it also strengthens our hypothesis with the possible use of a maximal length.

The second objective is analysing how performance evolve along the track. We are in particular interested in defining and identifying the limit when carriage becomes inefficient.

b) Materials and methods

This experiment is realized with a U-shape blade we designed. The model (LEGO) pushes the material all along the track. We made the experiments with flour for two reasons: 1/we can make clean cut and shape the track very precisely, 2/the clean cut make it easier to take samples every 5 cm. The field with material to excavate is prepared as follow: a rectangle of 11,6 cm width per 165 cm length with a thickness of 3 mm, then 5 mm and finally 8 mm (fig. 6). The material lost and dumped on the side of the track is collected per 5 cm segments (figure 7a and 7b) and weighted with a digital scale with 1 g sensitivity. The sampling distance was chosen short enough in order to have sufficient measurements and long enough in order to be in the measurement range of the digital scale.

Fig.6: Track prepared with floor

In order to have a direct reading of measure of the quantity of material ejected on the sides we have set the width of the material spread on the ground equal with the width of the blade. Consequently there is no inactive material that stays on the side of the system which should be subtracted in the weight measurements.

(a)

(b)

Figure 7: Overview of the track after dozer passage and 5 cm samples

10 repetitions are done for each thickness. 3 different thicknesses are tested. Table 2 presents the plan for the experiment.

Tab.2: Plan for the experiement

Thickness	Thickness scaled to real size (x 16)	Repetitions
3 mm	4,8 cm	10
5 mm	8 cm	10
8 mm	12,8 cm	10

Results

The weight of the material ejected for the three or four first sections was under the detection capacity of the electronic scale. To overcome this problem we have collected the material of the 10 repetitions and made a calculation of the average weight. As a consequence the first four values are not usable in the variance estimation.

The table below summarizes the standard deviation values calculated with 10 repetitions. The standard deviation values are ranging from 0 to 1,43 with an average value of 0,64.

Tab.3: Different deviation results

Mean stand dev. 3 mm	0,5
Mean stand dev. 5 mm	0,58
Mean stand dev. 8 mm	0,84
Mean stand. dev.	0,64
Max. stand. dev.	1,43

Observing the carriage process we made the following qualitative observations:

- The material primarily accumulate in front of the blade evolving in a parabolic profile outstripping the blade.
- The parabolic profile seems to grow horizontally until a limit
- The material accumulation grow up vertically.
- The quantity of material left on the side increase regularly and seems to reach a maximal value.
- When the blade seems filled to capacity, the incoming material get around the accumulated material and is dumped on the side.

The figure 8 below introduces the results of the experiment with the three thickness categories tested. Each point plotted in the scatter is the averaged value for the 10 measurements done (weight of material dumped on the side for the 5 cm sections at the distance indicated in abscissa).

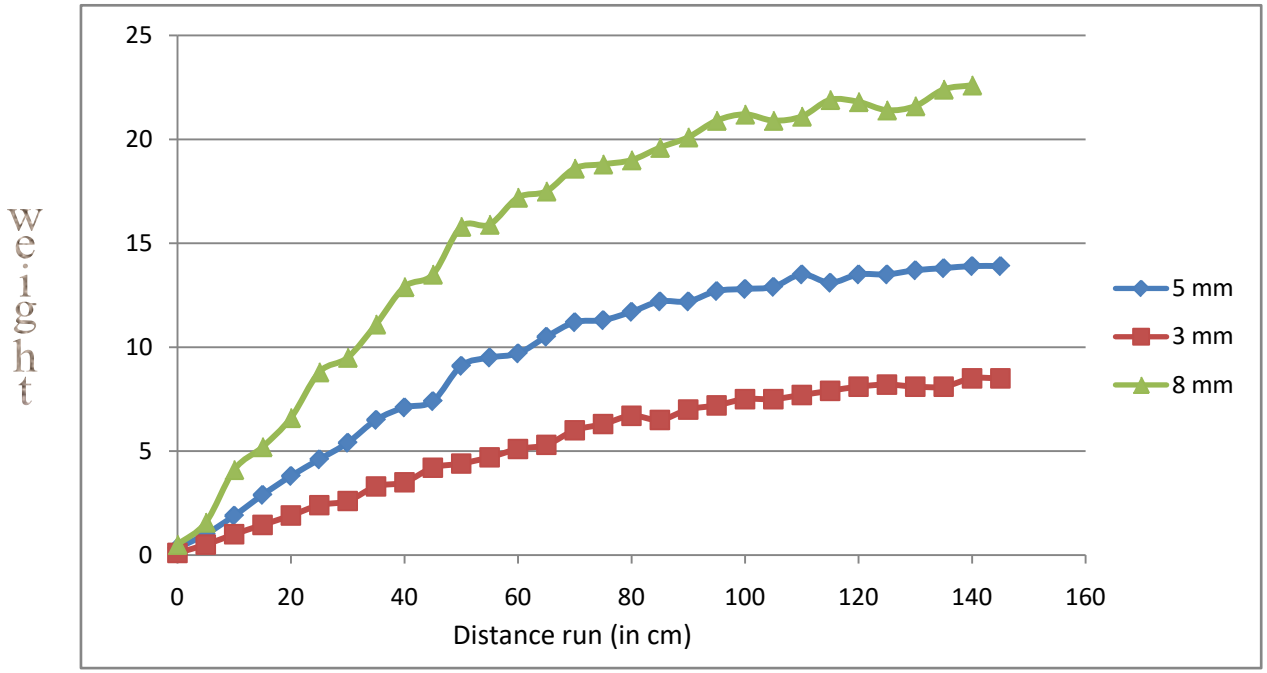

Fig 8: Variation of the average weight ejected on the side with the distance with 3 different thicknesses

Interpretation

The right interpretation of the standard deviation values requires their comparison with the range of the measures (from 2 g to 25 g) and with the sensitivity of the digital scale (1 g). In this respect we excluded the smallest values (< 4g) because the inaccuracy of the measurement is too important compared to the value of the standard deviation. In the case of the remaining values, we can see that the standard deviation is quite low compared to the values. We can conclude that the carriage process is reliable in the range where the measurement inaccuracy becomes negligible. Additionally the regularity of the curves profile we obtained indicates that the repetition number seems sufficient in regards of the variances.

The curve profile confirms the quantitative observations we made. The amount dumped on the sides by the dozer gradually increase until a limit (materialized by the horizontal asymptote of the curve). We suppose that when the blade is filled to capacity all the material moved by the blade is ejected out on the side. Consequently the measurement of the weight of the material on a 5 cm x 11,6 cm section should provide an estimation of the asymptotic value. In order to calculate a precise value we made the weight measurement for a 150 cm x 11,6 cm section for the three different thicknesses and them retrieve the corresponding 5 cm value by making a cross-multiplication . The table below summarizes the results.

Tab.4: Total weight measured for 150 cm and weight calculated for 5 cm with the 3 categories of thicknesses.

Thickness of the layer	Total weight (for 150 cm)	Weight for 5 cm
3 mm	274 g	9,1 g
5 mm	461 g	15 g
8 mm	681 g	22,7 g

At first look, the curve roughly reminds a A. $(1 - e^{\lambda x})$ progression with horizontal asymptotic ending. The consequence is a faster diminution of the equipment performance in comparison with a linear performance progression. This is an important result to consider later on with the planning of the moves of the dozer; shorter push lines would theoretically be advantageous over longer lines.

The following development demonstrates how performance assessment can be done. Considering 8 mm thickness layer, the maximal weight ejected is 22,7 g. When the blade ejects 11,35 g is has already lost 50% of performance. We can see 50% performance limit is almost reached in the first third of the run (with a distance of 35 cm out of a 110 cm maximal run).

Tab.5: Performance estimation using the curve

Thickness	Max ejection	ejection at half performance	Abscissa value at half performance
8 mm	22,7 g	11,35 g	≈ 35 cm
5 mm	15 g	7,5 g	≈ 42 cm
3 mm	9,1 g	4,55 g	≈ 50 cm

The figure below shows how we used the curve to make performance calculation in tab. 5.

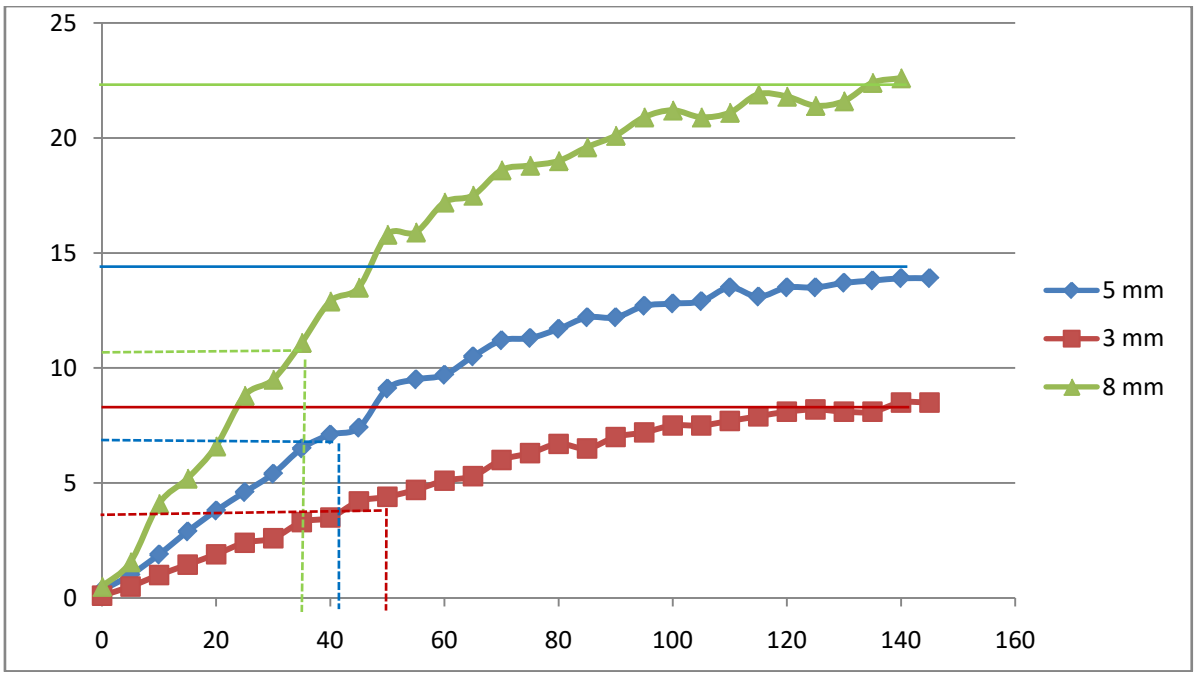

Figure 9: Weight of ejected material

The examination of second partial derivate shows the capacity loss grows proportionally with the distance in a first stage (with $\partial^2 f / \partial x^2 \approx 0$); then the values of the second partial derivate become negative (with positive values for the partial derivate) showing a decrease in the growth of the capacity loss.

The table below provides the value we were able to get with a linear regression with the first part of the curve and specifies the range of the data we used for this.

Tab.6: Results of linear regression made on the first part of the performance curves.

	Distance range	a	b	r
3 mm	0 to 80 cm	0,08	0,23	0,998
5 mm	0 to 70 cm	0,16	0,52	0,996
8 mm	0 to 50 cm	0,3	0,71	0,997

c) Conclusion

With the analysis of the standard deviation between 10 repetitions for 3 x 30 values we first demonstrated that the carriage process is reliable. The reliability makes the planning theoretically possible at model scale.

With the curve profile analysis we demonstrated that a target performance value can be set and the corresponding maximal carriage distance can be determined. As dozers or loaders have to do earthwork with go and return it appear the most efficient strategy is to favour short lines (if only considering dozer). Short lines results in better efficiency as regards to lateral ejection. Longer line results in the ejection of more material. So this first experiment validate our hypothesis. The conclusions drawn here are of fundamental importance for the sustainment of our approach; never the less as it was introduced the performance of the blade is hardly exploitable in the field. Experiment 2 aims at continuing with performance issues consideration, but with parameters (the pair percentage of overlay / maximal length) exploitable in the field and with the planning.

V. Analysing the Relationship Between Overlay and Maximal Line Length

a) Aims and objectives

This experiment aims at testing the effect of the overlay on the maximum carriage distance. In this work the maximal carriage distance is defined as follows: the maximal carriage distance is reached when material start to be ejected on the side of the machine equipment.

b) Materials and methods

This experiment is realized with a U-shape blade. A test consists of 6 contiguous passages with a given overlay so as 5 ejection lines remain on the field. The length of passages is set long enough so as ejection happens on the side of the blade. The distance between the start point and the point where ejection happen is measured. Overlay between passages is increased from 0% to 40% by increment of 5% (tab. 7.).

Tab.7: Experiment plan for overlay test

#	Blade	Overlay in %	Overlay in cm	Number of repetitions
1	U-shape	0	0	10
2	U-shape	5	0,6	10
3	U-shape	10	1,15	10
4	U-shape	15	1,75	10
5	U-shape	20	2,3	10
6	U-shape	25	2,9	10
7	U-shape	30	3,5	10
8	U-shape	35	4,05	10
9	U-shape	40	4,65	10

It is almost impossible to follow perfect parallel lines with the model. A deviation from the theoretical navigation line generates variance with the measurements. In order to avoid the apparition of bias caused by trajectory deviations we decided not to use the wheel loader model. The bucket was mounted on a bridge crane specially designed for the experiment (fig. 10.).

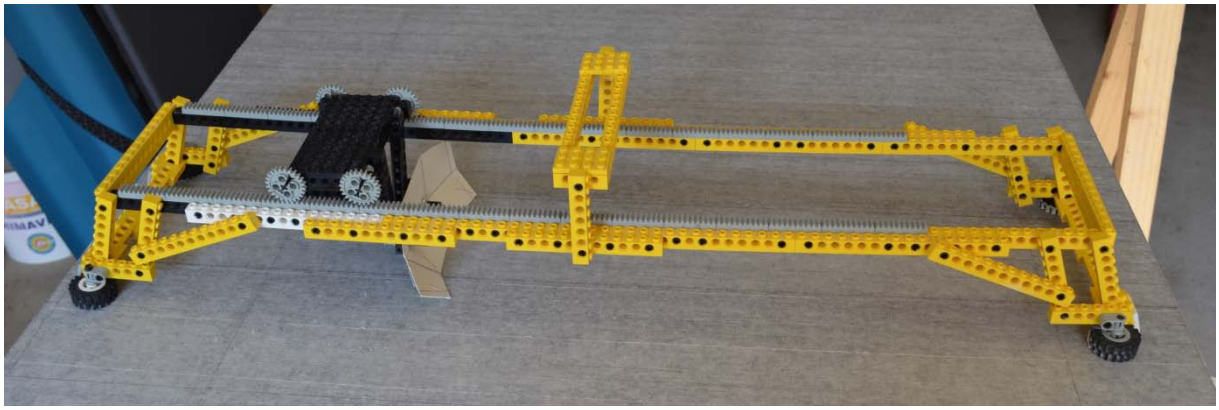

Fig.10: Bucket mounted on bridge crane

A video record of part of the process was prepared and is available online: link here.

Results

Fig.11: Field work after completion of 9 push lines

The results of the measurement are plotted in the figure 4. At first glance it seems the overlay percentage and the maximal push length correlate.

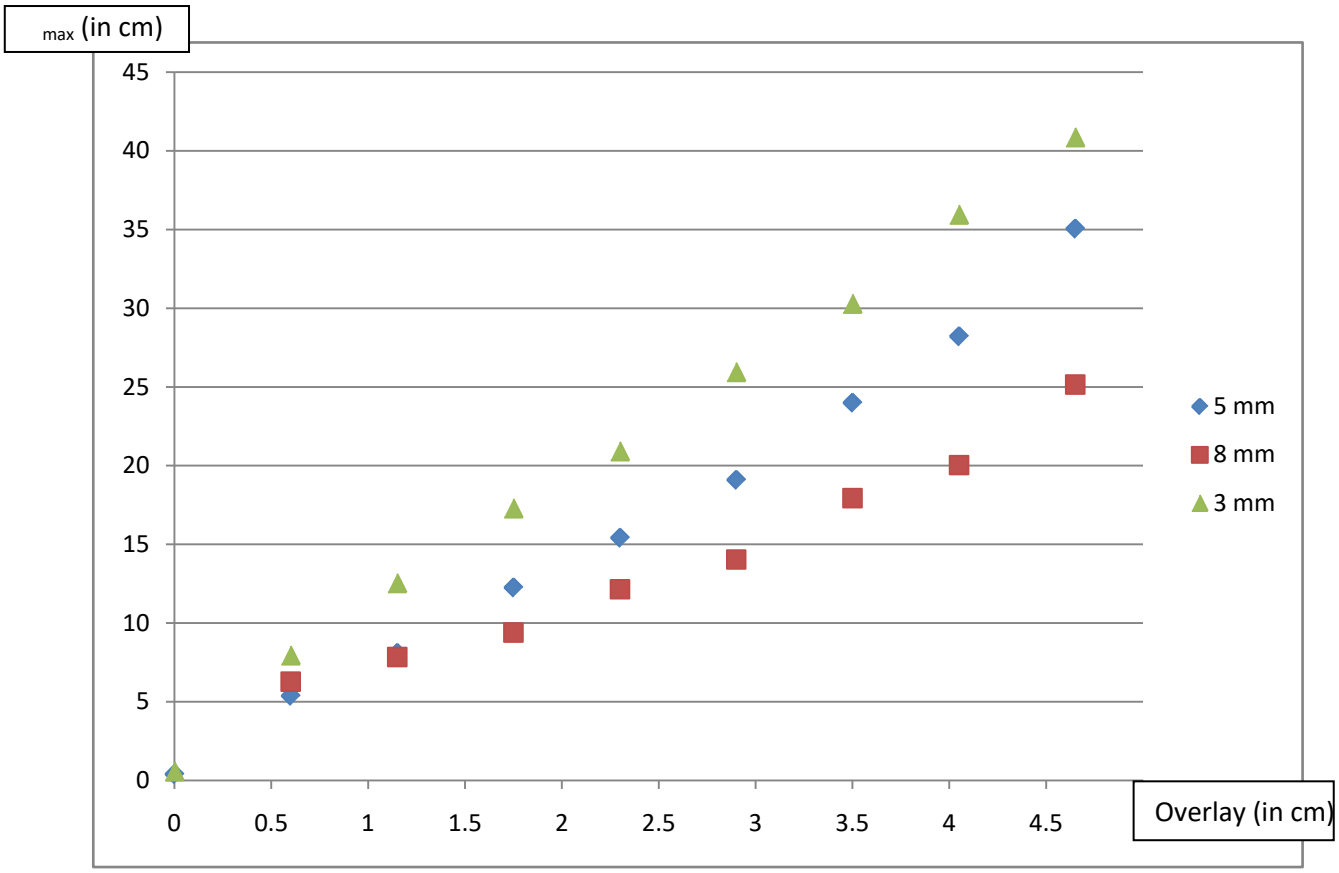

Fig.12

Interpretation

The observations are again characterized by a small variance which shows the reliability of the method/process.

The regularity of the curves shows that sufficient repetitions were done.

The two lowest values collected for the 8 mm test seem located higher than they we would logically expect.

Seeing how points are aligned on the scatter we suggest proceeding with a linear regression.

Tab.8: Results of linear regression

	a	b	r
3 mm	8,31	2,08	0,998
5 mm	7,07	0,028	0,9952
8 mm	4,54	2,26	0,986

The high values with the r coefficient show the overlay correlate well with the maximal length for the three different thicknesses.

c) *Conclusion*

This experiment confirmed that the maximal push length correlate with the overlay between push lines. Moreover as the values with correlation coefficient (r) are satisfying, we can conveniently model the relation between the overlay and the maximal length with linear functions. This experiment also demonstrated the reliability of the measurements/process. It is an important issue in particular if this procedure is used later on as a calibration procedure. In the following developments, the 3 linear functions we calculated will be integrated in a model where the total length run by the different types of equipment will be calculated; then the balance between the lengths (dozer and excavator) will be considered with the aim to optimize the move of the equipment.

VI. Optimization Tool Development and Method Generalisation

a) Strategy

We decided to detail how the optimization tool was developed in the case of the dozer / excavator cooperation. A first reason is that it constitutes the most elaborated case. The second reason is the pair dozer /

excavator can be used in any kind of environment and conditions. Last, it is the most common equipment. The cases employing the motor grader and wheel-tractor scrapper are briefly explained afterward.

To develop the tool we started from the beginning of the workflow (earthwork of the dozer) and from the operational and spatial constraint: the whole polluted area should be processed with the appropriate overlay. The overlay is the key parameter and our main variable in this case; it conditions the number of lines per unit of area. So the problem consists in calculating how many passage widths fit into the area width (calculation including a variable overlay parameter) and how many l_{max} fit in the area length (l_{max} also as a variable calculated with the calibration function from the overlay value). Then a second constraint was added to the system to arbitrate the balance between dozer and excavator with their respective "costs". But several questions should be considered when thinking about the balance issue between the costs of dozer and excavator: 1/On which base to make it? 2/What should be part of the cost, what should not be? Regarding 1/ it would not make sense to use hourly costs as we have no input parameter for time; neither we have idea about the time balance for the two different equipment. So the cost should be approached based on (a) volume or (b) based on run distance. Question 2/ help for decision making. Taking the case of the excavator, the volume to collect will remain the same (the volume of the contaminated fraction of soil) whatever l_{max} value is; volume does not vary with the variables. The volume will simply be spread differently in space with more or less dump. So what will vary (as cost to reduce) is the travelling distance for the excavator when visiting more or less dumps lines. So in the case of the excavator the linear cost for the visit of lines makes sense. Is distance also relevant for the dozer too? Yes as far as all the pollution is collected, i.e. spatial coverage is respected. And this is insured by the spatial coverage calculations with the number of line calculation in width and length from geometry and overlay. Additionally, apart the collect work, the dozer should move its own weight on the total distance which is still high in energy consumption and cost as dozer is really heavy equipment. So it makes sense to use linear travel value for optimization. To recapitulate, we only consider the costs varying with the set of variables, and weighting derive from the ratio between the varying costs (cost varying opposite as seen in part 1). Finally, thinking about the comparison of cost for operating bulldozer and excavator moving empty, the cost of the excavator would probably only influence the total cost to a limited extend. This hypothesis should be tested.

b) Details about the calculations

Table 9 introduces all the input parameters and intermediary variables used in the calculation tool.

Tab 9: Cell name inventory (in green)

Input parameters			Max lenght calculation function		
			3	5	8
Area width (m)	Area_width	a	8,31	7,07	4,54
Area length (m)	Area_length	b	2,08	0,028	2,26
Bucket size (cm)	Bucket_width		Table_coef_calc_max_length_from_overlay		
Dozer length (cm)	Dozer_length				
Overlay (percent)	Overlay				
Cost per linear meter dozer	Cost_linear_meter_dozer				
Cost per linear meter excavator	Cost_linear_meter_excavator	Table_linear_costs			
Thickness targetted (mm)	Thickness_targeted				
Line change manoeuvre coefficient	Manoeuvre_coefficient				
Intermediary calculations					
coef dozer	Dozer_coef				
coef excavator	Excavator_coef				
Number of line in width	Line_number_in_width				
Max line length (cm)	Max_line_length				
Number of line in length	Line_number_in_length				
Total route dozer (m)	Total_route_dozer				
Total route excavator (m)	Total_route_excavator				
Total route dozer weighted	Total_route_dozer_weighted				
Total route excavator weighted	Total_route_excavator_weighted				
Sum total route weighted	Sum_total				
Results					
Optimal overlay	Overlay				
Optimal line length	Max_line_length				

The strategy and calculations for each intermediary cell are detailed below.

Coef dozer/coef excavator

The excavator and the dozer are performing two different types of work and we assume they have not the same costs. So the way the two workloads are balanced influences the final cost. If dozer lines are longer, there will be fewer lines to collect for the excavator. So dozer cost increases (because the dozer work plan will contain more overlay and dozer will push on longer so more mass); excavator cost are lowered. Reversely if the dozer makes shorter lines the excavator will have more lines to visit and collect. So excavator moves are increased whereas dozer costs are lowered. So the main question is how can we find the good balance between the two kinds of operations. To solve this issue we have introduced two entry values (one is the cost per linear meter for the dozer, the second is the cost per linear meter for the excavator) and a coefficient is calculated in order to be able to weight the distance run by the two types of equipment. To set the coefficient, we find out which equipment is the most costly (on an linear measurement base) and express how many times it is in comparison of the other.

Number of lines in width

This calculation aims at knowing how many lines cover the width of the work area. The first step in this calculation is to subtract the width of the dozer blade to the width of the work area (fig. 6). Then in the remaining width space we calculate how many tracks (reduced by the overlay value) are fitting. If this number is an integer, then the final number is the division result + 1. If the division result is not an integer, the cell receives the integer of the division +2.

Max line length

This value is calculated using the calibration curves from experience 3. The overlay value is expressed in cm as percentage of the bucket width.

Number of line in length

Similarly to 'number of lines in width' this value, which is not an integer, is obtained by the division of the length of the area by the maximal length on the line.

Total route dozer

This route calculation cumulate the go and return of the dozer. There are 'number of line in length' × 'number of line in width' × 'max line length' for the go, and the same value augmented by a manoeuvre distance value for the change of line. The manoeuvre length is obtained by the multiplication of the dozer length by a manoeuvre coefficient that we expect to be within the range of 1,5 to 2,5 times the dozer's length.

Total route excavator

This total route cumulates the route for collecting the material dumped and the route to join the line oriented in width.

Total route dozer weighted / Total route excavator weighted

These values are the total route calculated above multiplied by the respective coefficients.

Sum total route

The sum of the two weighted routes.

Finally the calculation of the optimal overlay is performed using the Excel solver add-in. Sum_total is set as the objective to minimize. The decision variable is set to "Overlay". The constraints are set as follows: "Overlay <= 40" and "Overlay >= 5".

Calculations are simple in the case of motor grader use. The width of the area should be divided by the width of the blade plus the dump width. As there is no loaded capacity engaged, consequently there is no maximal length calculation nor overlay calculations needed.

The model associated to the scrapper should take into consideration an overlay value between passages. As the scrapper has a capacity value, we consider the same calibration approach could be used to determine the l_{max} / overlay correlation. Calculation sheet has been reviewed to integrate the difference with the geometry.

The different calculation sheets with calculation details are available for download at the following address: put address here.

Exploitation and results

The set of values used to test the effect of parameters on optimization are gathered in table 10. Very interesting observations can be done and interesting conclusions drawn.

Tab.10: Set of parameters for test run

Ref.	Coef dozer	Coef Excav.	Manoeuvre coef	Overlay solver	Total route dozer	Total route excavator
a	1	0	2	30.2	4050m	/
b	1	0	1,5	28.4	3652m	/
c	1	0	0	5	2460m	/
d	1	1	2	32.9	4076m	390m
e	1	0,25	2	31.8	4063m	400m

(a) is considered as the reference scenario. It only uses the dozer, not the excavator. The resulting optimized overlay is 30,2%. In (b) the coefficient for manoeuvre was reduced to 1,5. The optimal overlay

decrease by 1,8%. Run (c) (not realistic) tests a run without manoeuvre just for checking if the solver reacts as expected. As expected the minimum overlay 5% is calculated as optimal. The conclusion is manoeuvre move represent an important part of all the moves and it should really be considered. Run (d) introduce the excavator in the optimization calculation with a coefficient equal to the dozer (strong in regards of reality). Overlay increase by 2.7% (so it is quite limited). Scenario (e) tests a much more reduced ratio (which is aimed at being closer to reality) between the dozer and excavator. Difference with overlay is 1,1% and total dozer route varies less than 0,5%.

The figure below shows how the total route varies with the overlay in the case of the dozer (blue series) (coef dozer = 1, coef. excavator = 0). Several observations can be done. The first observation is that evolution is not linear and a minimum can be observed in the middle part of the curve at 30,2%. Comparing the smallest overlays (<15%), the total route variation is very important. For overlay over 20%, the route varies much less. In this situation, it is more efficient to perform more important overlays. This situation is caused by the effect of the length of the turn manoeuvre. The green series represents the route without manoeuvre, so the difference between the blue and the red series is the manoeuvre effect. When the lines are short (and overlay is small) the change line manoeuvre becomes a significant percentage of the total route which decreases the efficiency of the moves of the dozer. Over 20% overlay, the total route variation only varies by 6%. On one hand 6% is significant; on the other hand with the perspective of optimization it is not that much.

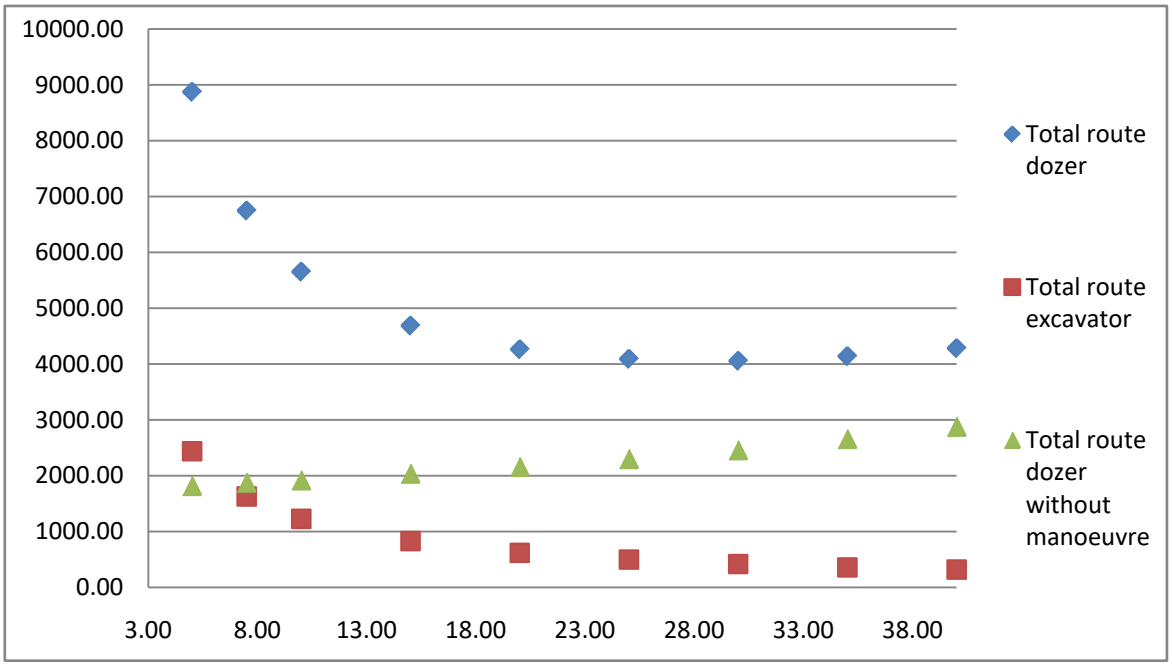

Fig.12: Evolution of total distance for the equipment in function of the overlay.

Last, the red series figures how total route for the excavator varies with the overlay. Variation has not a linear shape and decrease when overlay increase. In consequence the optimization of the combined use of the two equipments is located a bit above the minimum of the blue series. It satisfies almost the minimum value for the dozer and a minimal value for the excavator. As the excavator curve decrease more than the one of the dozer increase, it logically favour the excavator, that's the reason why the optimal overlay is a bit above the minimum value for the blue curve.

VII. Discussion

The experiments are done with scale models. This raises the following fundamental question: are all the results transferable from the 1:16 scale to 1:1 scale? Our beliefs are as follows: the complete method is transferable whereas the sets of optimized parameters calculated at 1:16 are not. The method is applicable at 1:1 scale because the physical basis generally works the same for the scale model and for the equipment in the field (forces, volume capacity, input/output balance with the bucket, spatial coverage, etc.). The optimized parameters are not robust for scale transfer (the balance of forces differs from model to 1:1 scale (friction, forces values, excavated material characteristics are different). The calibration method should be applied in the field with the equipment, data extracted and processed to extract terrain situation values for the pair overlay / l_{max}.

The method we set up works on simple basis and it can easily be implemented in the field. A navigation plan has to be set with for example 8 lines. The overlay between the passages can be increased by

5% from 0 to 40% from line 1 to line 8. Then l_{max} is measured and associated to the different overlays. This calibration has to be done for: 1/ the different thickness that should be implemented, 2/ the different bucket that will be used. We do not see any usefulness to model the parameters variation based on thickness variation and rather propose to perform a case-by-case calibration.

In the geo-processing model we built the overlay parameter does not exist; but still it can be solved. The geo-processing tools should be run with a parcel width of bucket_width × (1 – overlay). This way the field implementation will be larger by ½ overlay on each side compared to the plan, establishing the desired overlay.

The homogeneity of terrain should be assessed and the impact on equipment efficiency assessed as well. It is important to know if it is worth doing diverse calibrations to get different sets of optimized parameters for the different soil types.

Overlay value is expressed as a percentage the blade width. This means calibration has to be done for any blade type use in the field. This is not practical because lot a calibration needed.

Coefficients for dozer and excavator should primarily come from expert estimates. It is not the most accurate but it is worth for a start. Then, when operational data will be available (from the tracking done with positioning equipment) data mining should be used to extract more accurate data. From this, the set of parameters can be recalculated. Many sources mentioned the efficiency of data mining technique to have realistic assessment of equipment efficiency/costs (Parente, 2016, etc).

Optimization of the spatial coverage requires having minimal overlay between passages and minimal overlay is possible only if the lines are short. So first conjecture is optimization should favour the shortest lines. But using appropriate parameters and modelling we demonstrated short lines are counterproductive because of the "cost" of manoeuvre. Consequently the calculated optimal line is shifted to a higher value. And the value is shifted even a bit higher when the excavator travel costs optimization are integrated. We ended up with two extreme overlay values of 30,2% (excavator not integrated) and 32,9% (excavator dozer balance of 1/1) which are quite close each over. Excavator effect in optimization exists, but is limited.

Decision making is a complex process in the case of soil remediation. Many factors should be considered (like the remediation efficiency objective, time constraint, soil characteristics, thickness to excavate, equipment available) to select, adapt and even develop the appropriated remediation approach. It is not possible to cover this topic exhaustively (and obviously as we were sorting things out) but we have tried to the extent of possible to make a coherent approach, with classical operational basements. We also attempted to widen the implementation possibilities and provide threads in varied directions. The next research work will focus on technical proposal for machine navigation, machine control (including grading control) in order to precisely met remediation objectives and excavate only polluted soil. When this last part will be set up, industry will have at disposal a complete and coherent approach for precision excavation implementation.

VIII. Conclusion

Bibliographic research on our specific topic has not brought relevant information. Paving the way, we sometimes had to introduce and develop our own vocabulary and concepts. Occasionally we could get inspired by existing work from the field of earthwork optimization.

The experiment on collect efficiency made with a scale model of dozer confirmed the hypothesis: collect efficiency decrease all along the path while the bucket gets filled and while lateral ejection increase to a maximum.

The calibration approach tested with scale model was successful. It allows correlating overlay with maximal line length. We believe it is replicable in the field with the equipment with a simplified protocol (as many measurements are necessary) to measure overlay/l_{max} values and to be able to build calibration curves.

Optimization tool was developed around a first set of key parameters: overlay and l_{max} value, linear computing and the use of a solver tool. Trying different test scenarios with different parameters combination it turned out not only overlay and l_{max} are of critical importance, but also the length of manoeuvre for line change. The tool definitely helps to test many variations and to rationalise decision making regarding overlay strategy, effect of manoeuvre and effect of equipment on costs. It clearly showed the limited interest of excavator cost integration in the optimization process (total run distance changes between scenarios inferior to 1%), but on the opposite clearly showed the important effect of manoeuvre on total distance (0,5 pont change with manoeuvre generate 1,8% change with overlay and 10% change with total distance). Taking the full range (5 to 40%) of overlay, the total distance varies very much 119%. Taking only the values over the optimum a 10% variation of overlay produces only 6% of variation with the total length.

After the run of the solver, two parameters should be used in the geo-processing tool we formerly designed for work planning: the overlay (parcel width = bucket_width × (1 – overlay)) and the maximal line length (parcel length = maximal length).

Further optimization of remediation work is possible by employing the techniques described in the literature, in particular fleet balancing techniques.

Future work will consist in making proposal with equipment for machine navigation, machine control (in particular grading control) to achieve grading and excavation precisely.

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Particle Swarm Optimization with Family Communication Strategy

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Abstract- Particle swarm optimization (PSO) is a population-based stochastic algorithm for solving complex optimization problems. To raise efficiency and accelerate convergence of PSO, we proposed a new sociological PSO algorithm with family concepts, named as FPSO. Here, family relationships and relative communication strategies were introduced into the conventional PSO algorithm. Two types of family relationships among particles: equal relationship (ER) and generational relationship (GR) were introduced into the communication strategies among family members. The convergent speed and complexity of the proposed FPSO method were analyzed theoretically, and simulated by the IEEE-CEC 2015 learning-based benchmark problems to demonstrate the precision and convergent speed. And, the FPSO performances with ER and GR were separately tested and discussed. The experimental results indicated that the proposed FPSO method could improve the convergence performance, and had stronger judgment ability and intelligence than the conventional PSO method.

Keywords: *particle swarm optimization; family; equal relationship; generational relationship.*

GJCST-G Classification: *B.4, B.4.1*

Strictly as per the compliance and regulations of:

Particle Swarm Optimization with Family Communication Strategy

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Abstract- Particle swarm optimization (PSO) is a population-based stochastic algorithm for solving complex optimization problems. To raise efficiency and accelerate convergence of PSO, we proposed a new sociological PSO algorithm with family concepts, named as FPSO. Here, family relationships and relative communication strategies were introduced into the conventional PSO algorithm. Two types of family relationships among particles: equal relationship (ER) and generational relationship (GR) were introduced into the communication strategies among family members. The convergent speed and complexity of the proposed FPSO method were analyzed theoretically, and simulated by the IEEE-CEC 2015 learning-based benchmark problems to demonstrate the precision and convergent speed. And, the FPSO performances with ER and GR were separately tested and discussed. The experimental results indicated that the proposed FPSO method could improve the convergence performance, and had stronger judgment ability and intelligence than the conventional PSO method.

Keywords: particle swarm optimization; family; equal relationship; generational relationship.

I. Introduction

Particle swarm optimization (PSO) is an evolutionary computation algorithm which is motivated by the social behavior of organisms, such as bird flocking [1]. As a popular research topic, it has been successfully applied into the applications of biomedical image segmentation [2], medical dataset classification [3], magnetic resonance brain classification [4], electroencephalography [5], etc..

Although the traditional PSO method is easily implemented, it is sometimes suffered from premature convergence, especially in the complex multimodal problems. Therefore, a lot of derived PSO algorithms have been proposed to accelerate convergence speed and avoid the local optima. Such as, Chu et al. [6] presented the parallel PSO (PPSO) according to the independence of the data. The performance of the PPSO is highly dependent on the level of the correlation between parameters and the nature of the communication strategy. Sun et al. [7] introduced feasibility-based rules and a turbulence operator to overcome the premature convergence. Suganthan [8] presented a variable neighborhood operator where the neighborhood of a particle was composed of the several closest individuals every iteration. Kennedy et al. [9, 10] analyzed that the topological structure of the population controlled its exploration and exploitation tendencies. Especially, Marco et al. [11, 12] proposed a heterogeneous PSO algorithm and studied the interactions from the particle level to the swarm level. Their method demonstrated that two different types of particles usually performs better than those with the worst of the two homogeneous variants.

Based on the heterogeneous points in Ref.[11,12], we noticed that biology was divided into different levels, such as individual, family, population and ecosystem. Among them, family is a common activity basic form of life. Each family needs to enhance collaboration among family members and compete for the resource with other families. For example, a typical elephant family [24,25] usually comprises 6 to 12 individual elephants to build a very complex family structure. And the elephant family consists of an older matriarch and her descendant. When traveling vast areas in search for food, the herd in a elephant family is led by the matriarch. The others follow her footsteps in single _le. So, when family is considered as a unit, the relationship of family members will be very important. There are different constraint relationships between family members. Such as, an equal relationship (ER) exists between husband and wife or between siblings; a generational relation (GR) exists between parents and children. The phenomena present that the different types of relationships among family members mean the different family communication strategies.

In this paper, we applied a sociological conception, as similar as family, into the PSO method, named as PSO with family communication strategy (FPSO). The proposed particle swarm consisted of different families and each family consisted of different members. The different relationships between members, the ER and the GR, were built for the different structures of the communication strategies among family members. Here, the FPSO methods of the equal and generational relationship were respectively named as the ER-FPSO and the GR-FPSO. The convergent speed and the temporal and spatial complication of the

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proposed FPSO methods were studied by six benchmark functions in the experiments. The experimental results illustrated that the proposed FPSO methods could get the better convergence performance than before.

The rest of the paper was organized as follows. In Section 2, the background of the PSO was described briefly. In Section 3, the proposed FPSO and its communication strategies were provided. Then the convergent speed and the complexity of FPSO were analyzed. In Section 4, the simulation results were presented to demonstrate the performance of the different algorithms. Conclusions and the proposal for future research were given in Section 5.

II. Overview of the PSO

In the conventional PSO algorithm, an individual particle i is composed of three vectors: its position in the D-dimensional search space $x_i = (x_{i1}, x_{i2}, ..., x_{iD})$, the best position found by itself $p_i = (p_{i1}, p_{i2}, ..., p_{iD})$, and its velocity $v_i = (v_{i1}, v_{i2}, ..., v_{iD})$. Particles are originally initialized in a uniform random manner throughout the search space. These particles then move throughout the search space by a fairly simple set of update equations. The algorithm updates the entire swarm by the following rules:

$$v_{id} = \chi(v_{id} + c_1\phi_1(p_{id} - x_{id}) + c_2\phi_2(p_{gd} - x_{id})) \quad (1)$$

$$x_{id} = x_{id} + v_{id} \quad (2)$$

where $\varphi 1$ and $\varphi 2$ are uniformly distributed pseudo random numbers over [0,1]; *d* has the range from 1 to *D*; *pi* is the personal best position; *pg* is the best position found by the swarm. The constriction factor χ is defined by Clerc and Kennedy [13]. Here, $\chi \approx 0.72984$, $c1 = c2 = 2.05$ are used to ensure convergence.

III. PSO with Family Communication Strategy

a) Description of the FPSO

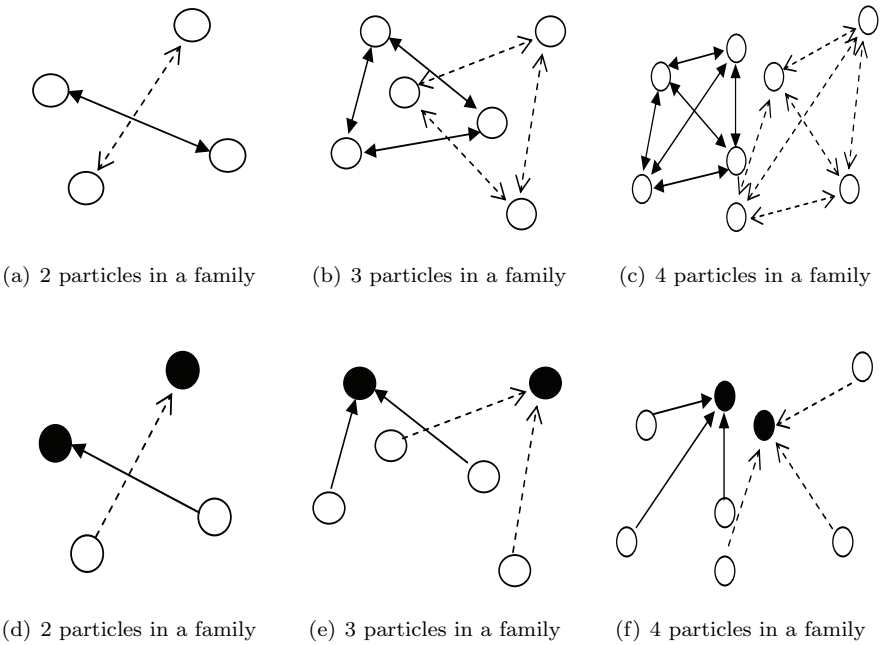
A family is a group based on marriage, blood or adoptive relationships. The family members maintain a close co-operation and form a common culture [14].The family is the smallest social unit. Generally, a family member can acquire the general information to affect its evolution by collaborating with other family members. And family members often share more information each other than strangers. Based on the mechanism of the natural family for information communion, the proposed PSO algorithms are proposed as follows.

The PSO has particles driven from natural swarms. The PSO combines the cognitive component with the social component [15]. The cognitive component represents the natural tendency of individuals to return to environments where they experienced their best performance. However, an individual's cognitive ability is smaller than that of the family in real life. Therefore, we introduce the concept of family in the proposed FPSO method. In FPSO, the particle swarm consists of different families. Every family has more than one member. Every member in the family provides the information based on the previous experience to other family members. So the cognitive ability of a particle will be changed and expanded through the family experiences. The preliminary results and the corresponding mathematical model of the proposed method can has been published in Ref.[26] and [27].

b) The communication strategy of the FPSO

In a family, the topological structure and communication strategy among members play vital roles at raising efficiency and accelerating convergence. The sociologist Fei Xiaotong [16] believed that a marriage contract included not only a relationship, but two kinds of associated social relationship: conjugal relationship and parents-children relationship. In fact, Conjugal relationship is the ER and parents-children relationship is the GR.

According to the sociological and anthropological points of view, two types of associated social relationship, the ER and the GR, were introduced into the communication strategy of FPSO. For the ER, different particles in a family are dependent and the family communication strategy is sharing information with each other. Their effects are equal in the search space. For the GR, different particles are divided into a parent particle and many child particles in a family. The family communication strategy is that the seeking behaviors of child particles are free and they give the information of their recent discoveries to their parent particle in the seeking processes. As an example of 2-4 particles in one family, the maps of different relationships and the corresponding family communication strategies among particles are shown in Fig. 1, where the arrows denote the flow of information and the different line styles mean the different families. The ER is showed in Fig. 1 (a)-(c) and the GR is showed in Fig. 1 (d)-(f), where the black nodes denote the parent particles.



(a) 2 particles in a family (b) 3 particles in a family (c) 4 particles in a family

(d) 2 particles in a family (e) 3 particles in a family (f) 4 particles in a family

Fig.1: The basic relationships and the corresponding family communication strategies between particles of two families

According the above types, the FPSO can be divided into the ER-FPSO and the GR-FPSO.

In the ER-FPSO, the position of each member is updated and the new fitness will be calculated every iteration in the family. Comparison of the all new fitness in the family, the best fitness is selected as the family fitness and the relative position as the family position of the current iteration. If this family fitness is better than the best family fitness that it has been found previously, this fitness will become the new best family fitness. When one particle finds the best family position, this particle will give a lead and other family members will move towards this direction. When another particle finds the new best family position in the next moment, this particle will give a new lead and other family members will move towards this new direction, and so on. So the velocity and position of particle i in the D-dimensional search space are updated by the following rules, if supposing particle *i* belongs to the *t*-th family:

$$v_{id}^{f} = \chi(v_{id}^{f} + c_1\phi_1(p_{td}^{f} - x_{id}^{f}) + c_2\phi_2(p_{gd} - x_{id}^{f}) \quad (3)$$

$$x_{id}^{f} = x_{id}^{f} + v_{id}^{f} \quad (4)$$

where *d* is in the range from 1 to *D*; p_t^f is the best position found by the *t*-th family and *pg* is the best position found by all families.

In the GR-FPSO, a parent particle and many child particles are included in a family. The parent particle decides how to moves according to the best solution found by its child particles and itself. The child particles act as persistent explorers and the parent as a decider. So child particles update their velocities and positions in the *D*-dimension search space by the following rules:

$$v_{id}^{c} = \chi(v_{id}^{c} + c_1\phi_1(p_{id}^{c} - x_{id}^{c}) + c_2\phi_2(p_{gd} - x_{id}^{c}) \quad (5)$$

$$x_{id}^{c} = x_{id}^{c} + v_{id}^{c} \quad (6)$$

where p^c is the personal best position and p_g is the best position found by all families. And, the parent particle updates the velocity and position in the *D*-dimension search space by the following rules:

$$v_{id}^{p} = \chi(v_{id}^{p} + c_1\phi_1(p_{td}^{f} - x_{id}^{p}) + c_2\phi_2(p_{gd} - x_{id}^{p})) \quad (7)$$

$$x_{id}^{p} = x_{id}^{p} + v_{id}^{p} \quad (8)$$

where p_t^f is the best position found by all members of the *t*-th family and p_g is the best position found by all families.

c) The convergent speed analysis of the FPSO

Whatever the ER-FPSO or the GR-FPSO, one of the outstanding characteristics is the best position of family p_t^f introduced into the FPSO. Therefore, when the convergent speed is compared between the PSO and the FPSO, *pi* and *pf* are analyzed mainly.

In the PSO and the FPSO, suppose that the benchmark function $f(\vec{x})$ is a minimum optimization problem. The velocity of the *i*-th particle is updated by using different updating formulas.

One is the PSO formula:

$$v'_{id} = \chi(v_{id} + c_1\phi_1(p_{id} - x_{id}) + c_2\phi_2(p_{gd} - x_{id}) \qquad (9)$$

Another is the FPSO formula (the *i*-th particle belongs to the *t*-th *f*amily):

$$v_{id} = \chi(v_{id} + c_1\phi_1(p^f_{td} - x_{id}) + c_2\phi_2(p_{gd} - x_{id})) \qquad ( )$$

where χ, c1, φ1, c2, φ2, *vid*, *xid* and *pgd* are the same in Eqs. (9) and (10).

If assuming the *t*-th family has *pars* particles: *r*1, *r*2, $\cdots$, *rpars* and *r*1 = *i*, then the th particle belongs to the *t*-th family. So,

p^f_t is the best position of the t-th family, that is,

$$p^f_t = \{p_j | min\{f(p_i), f(p_{r_2}), \cdots, f(p_{r_{pars}})\}, j \in \{i, r_2, \cdots, r_{pars}\}\},$$

and then,

$$f(p^f_t) = min\{f(p_i), f(p_{r_2}), \cdots, f(p_{r_{pars}})\},$$

therefore,

$$f(p^f_t) \le f(p_i).$$

1)If $p^f_{td} = p_{id}$, then,

$$(p^f_{td} - x_{id}) = (p_{id} - x_{id}).$$

by Eqs. (9) and (10),

$$v_{id} = v'_{id}\ .$$

That is to say, if the best position of the *t-th* family is the same with that of the *i-th* particle in the x_d-component space, the movement of the *i-th* particle is equal whatever in the FPSO or in the PSO.

2)If $p^f_{td} > p_{id}$, then,

$$(p^f_{td} - x_{id}) > (p_{id} - x_{id}).$$

by Eqs. (9) and (10),

$$v_{id} > v'_{id}\ .$$

That is to say, if the best position of the *t*-th family is much further to the current position than that of the *i*-th particle in the x_d-component space, the *i*-th particle moves faster in the FPSO than in the PSO.

3)If $p^f_{td} < p_{id}$, then

$$(p^f_{td} - x_{id}) < (p_{id} - x_{id}).$$

by Eqs. (9) and (10),

$$v_{id} < v'_{id}\ .$$

That is to say, if the best position of the *t*-th family is much closer to the current position than that of the *i*-th particle in the x_d-component space, the *i*-th particle moves slower in the FPSO than in the PSO.

In Fig. 2, the movement of the particle i through two dimensional search space is shown. Because $p^f_t = p_i$ pi, the i-th particle moves according to the original plan. In Fig. 3, the x_1-component and x_2 -component of p_i, p^f_t, v^{k+1}_i and v'^{k+1}_i are shown. It shows that if $p^f_{t1} < p_{i1}$ $v^{k+1}_{i1} < v'^{k+1}_{i1}$; if $p^f_{t2} > p_{i2}$, then $v^{k+1}_{i2} > v'^{k+1}_{i2}$.

Note that, in the FPSO, v_{id} is automatically adjusted according to the best position of family particles. Therefore, the FPSO has more intelligent movement ability and the convergent speed is faster than the PSO.

d) The pseudo codes of the FPSO

Algorithm 1. The pseudo code of the ER-FPSO

```
Begin
    Population parameters initialization
    Family parameters
    initialization Do
        For each family
            Update each particle's velocity and
                position by using Eqs. (3) and (4),
                respectively.
            Determine each family's best position, p^f
        EndFor
        Determine the current global best positions, p_g .
    While stopping condition not satisfied
End
```

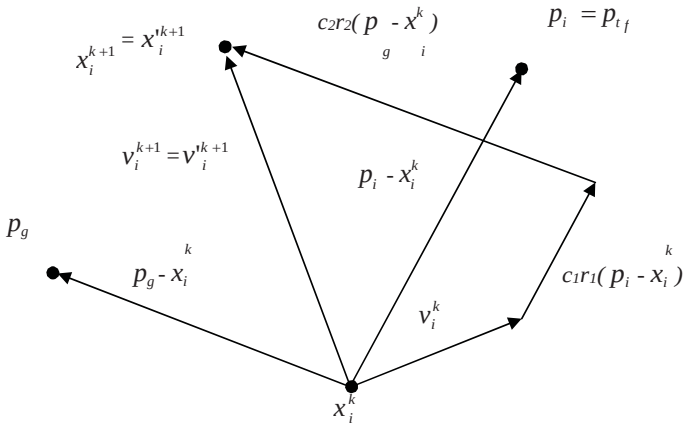


Fig.2: The movement of the particle i through two dimensional search space, $p_i = p^f$

Algorithm 2. The pseudo code of the GR-FPSO

```
Begin
    Population parameters initialization
    Family parameters initialization
    Do
        For each family
            If the particle is the child particle
                Update the particle's velocity and
                    position by using Eqs. (5) and (6),
                    respectively.
            EndIf
            If the particle is the parent  particle
                Update the particle's velocity and
                    position by using Eqs. (7) and (8),
                    respectively.
            EndIf
            Determine the personal best position, p^C_i
            Determine each family's best position, p^f_t
        EndFor
        Determine the current global best positions, pg .
    While stopping condition not satisfied
End
```

e) The complexity of the FPSO

Suppose a swarm of n particles includes m families and every family has *pars* particles (*pars* $>$ 1), i.e. $n = m * pars.(n > m)$. Let the i-th particle belongs to the t-th family, and $f(p_i)$ is the best fitness found by the i-th particle and $f(p_t^f)$ is the best fitness found by family members. In the discussion of the PSO, every particle need to save f (pi).

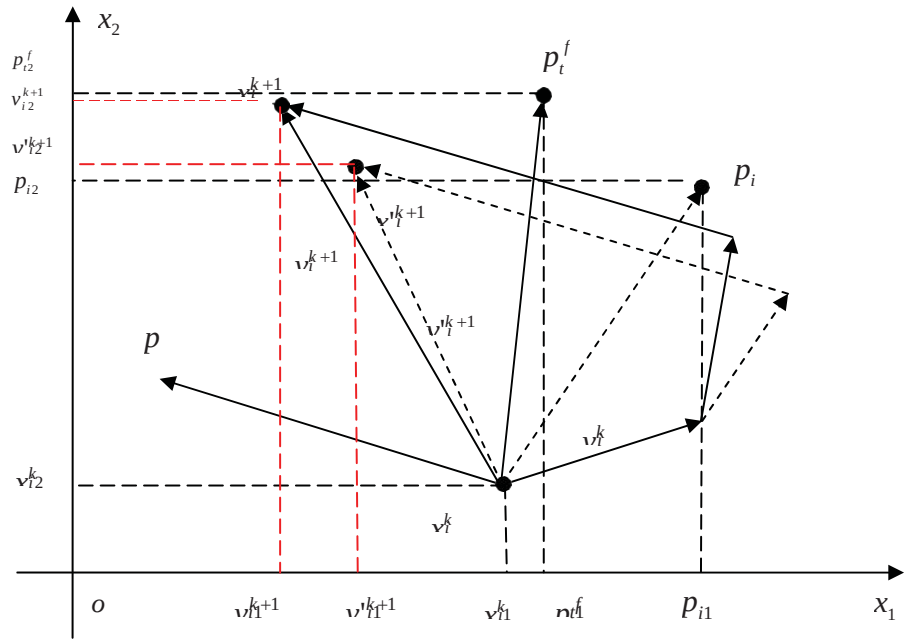


Fig.3: The movement of the particle *i* through two dimensional search space, $p_i = p^f$

Its elementary operation is comparing the fitness of the current iteration with $f(p_{ij})$. So

$$T_P(n) = O(n), \quad (11)$$

$$S_P(n) = O(n), \quad (12)$$

where $T_P(n)$ is the temporal complication of the PSO, and $S_P(n)$ is the spatial complication of the PSO.

In the ER-FPSO, every particle need not to save $f(p_i)$ but every family need to save $f(p_t^f)$. The elementary operation of every particle is comparing the fitness of the current iteration with $f(p_t^f)$. So

$$T_{ER}(n) = O(n), \quad (13)$$

$$S_{ER}(n) = O(m), \quad (14)$$

where $T_{ER}(n)$ is the temporal complication of the ER-FPSO, and $S_{ER}(n)$ is the spatial complication of the ER-FPSO.

In the GR-FPSO, every particle need to save $f(p_i)$ and every family need to save $f(p^f)$. Its elementary operation is comparing the fitness of current iteration with $f(p_i)$ and $f(p^f)$. So

$$T_{GR}(n) = O(n+m), \quad (15)$$

$$S_{GR}(n) = O(n+m), \quad (16)$$

where $T_{GR}(n)$ is the temporal complication of the GR-FPSO, and $S_{GR}(n)$ is the spatial complication of the GR-FPSO. Therefore, $T_P(n)$, $T_{ER}(n)$, $T_{GR}(n)$, $S_P(n)$, $S_{ER}(n)$ and $S_{GR}(n)$ satisfy the following formulas:

$$T_{ER}(n) = T_P(n) < T_{GR}(n), \quad (17)$$

$$S_{ER}(n) < S_P(n) < S_{GR}(n). \quad (18)$$

IV. Experiments

All algorithms were implemented on MATLAB (MathWorks, Natick, MA, USA). In order to analyze their performances, the IEEE-CEC 2015 learning-based benchmark problems on Learning-based Real-Parameter Single Objective Optimization were tested in the experiments, as listed in Table 1. A detailed description of these functions could be found in the Ref.[17]. The problem-specific parameters and the optimum function values were initialized for different methods implemented in the experiments under the following considerations:

1) Problem dimension: D=10,30.
2) Search range: $[-100, 100]^D$.
3) Runs / problem: 51.
4) Initialization: Uniform random initialization within the search space. Random seed is based on time, which is done using rand('state', sum(100*clock)).
5) the Max. number of function evaluations: *Max FES* = 10000 *D.
6) Global Optimum: All problems have the global optimum within the given bounds *Fi*.*

In order to facilitate the comparison, every family had the same number of particles. The algorithm name was abbreviated with the rule: particle number in every family and their relationship. For example, 2 ER denoted 2 particles in each family with equal relationship; 20 GR denoted 20 particles in each family with generational relationship. The traditional PSO [13] was be provided in the Matlab source code at CEC 2015 [28].

For the benchmark functions, record function error value ($f_i(x) - F_i^*$) after (0.1, 0.2, 0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0)*MaxFES for each run. $f^{0.9*MaxFES}$ denoted the error value of f_i after 0.9*MaxFES for each run. 10 error values were recorded for each function for each run. The best, worst, mean, median, and standard deviation values of the error value $f_i(x) - F_i^*$ found after MaxFES in 51 runs for both the PSO [13] and the ER-FPSO were listed in Appendix.

The results of 10 dimension data were shown in Table 4-8 and 30 dimension data were shown in Table13-17, respectively.

The comparison of the PSO [13] and the GR-FPSO were listed in Appendix. The results of 10 dimension data were shown in Table 9-12 and 30 dimension data were shown in Table 18-21, respectively.

Table 1: Mathematical representation of test functions

Type	Function	Description	F_i^*
Unimodal function	f1	Rotated High Conditioned Elliptic Function	100
	f2	Rotated Bent Cigar Function	200
Simple Multimodal functions	f3	Shifted and Rotated Ackleys Function	300
	f4	Shifted and Rotated Rastrigins Function	400
	f5	Shifted and Rotated Schwefels Function	500
Hybrid function	f6	Hybrid Function 1 (N=3)	600
	f7	Hybrid Function 2 (N=4)	700
	f8	Hybrid Function 3 (N=5)	800
Composition function	f9	Composition Function 1 (N=3)	900
	f10	Composition Function 2 (N=3)	1000
	f11	Composition Function 3 (N=5)	1100
	f12	Composition Function 4 (N=5)	1200
	f13	Composition Function 5 (N=5)	1300
	f14	Composition Function 6 (N=7)	1400
	f15	Composition Function 7 (N=10)	1500

The evaluation method for each algoritm was based on three scores which were given as follows:

$$Score_{10} = \sum_{k=1}^{15} mean(f_k^a)|_{D=10} + \sum_{k=1}^{15} median(f_k^a)|_{D=10} \tag{19}$$

$$Score_{30} = \sum_{k=1}^{15} mean(f_k^a)|_{D=30} + \sum_{k=1}^{15} median(f_k^a)|_{D=30} \tag{20}$$

$$TotalScore = Score_{10} + Score_{30} \tag{21}$$

where f_k^a denoted the average value of 10 error values for each run of f_k. The calculate method of f_k^a was given as follows:

$$\begin{aligned} f_k^a = 0.1 * (&f_k^{MaxFES} + f_k^{0.9*MaxFES} + f_k^{0.8*MaxFES} + f_k^{0.7*MaxFES} + f_k^{0.6*MaxFES} \\ &+ f_k^{0.5*MaxFES} + f_k^{0.4*MaxFES} + f_k^{0.3*MaxFES} + f_k^{0.2*MaxFES} + f_k^{0.1*MaxFES}) \end{aligned} \tag{22}$$

The $Score_{10}$, $Score_{30}$ and Total Score of PSO, 2 ER, 5 ER, 10 ER, 20 ER, 2 GR, 5 GR, 10 GR and 20 GR were shown in Table 2 and Figure 4. The resluts showed ER-FPSO had more efficience in the convergence performance than GR-FPSO. The Score10 showed the convergent precision of 20 GR was the best in GR-FPSO. To 20 GR, every family had 20 particles including 1 parent particle and 19 child particles. Nineteen positions and 19 fitness information were provided by 19 child particles to 1 parent particle. Nineteen child particles were only constrained by the best fitness found by themselves and they were free. One parent particle had more information and choices to decide how to move. Therefore, the parent particle had more intelligent and found better position and fitness.

To different types of test functions, four kinds of evaluation method were definited as the scores of unimodal, simple mutimodal, hybrid and composition functions. *Uni_Score*, *Sim_Score*, *Hyb_Score* and *Com_Score* were used, respectively.

$$Uni\_Score = \sum_{k=1}^{2} mean(f_k^a)|_{D=10} + \sum_{k=1}^{2} median(f_k^a)|_{D=10} + \sum_{k=1}^{2} mean(f_k^a)|_{D=30} + \sum_{k=1}^{2} median(f_k^a)|_{D=30} \tag{23}$$

$$Sim\_Score = \sum_{k=3}^{5} mean(f_k^a)|_{D=10} + \sum_{k=3}^{5} median(f_k^a)|_{D=10} + \sum_{k=3}^{5} mean(f_k^a)|_{D=30} + \sum_{k=3}^{5} median(f_k^a)|_{D=30} \tag{24}$$

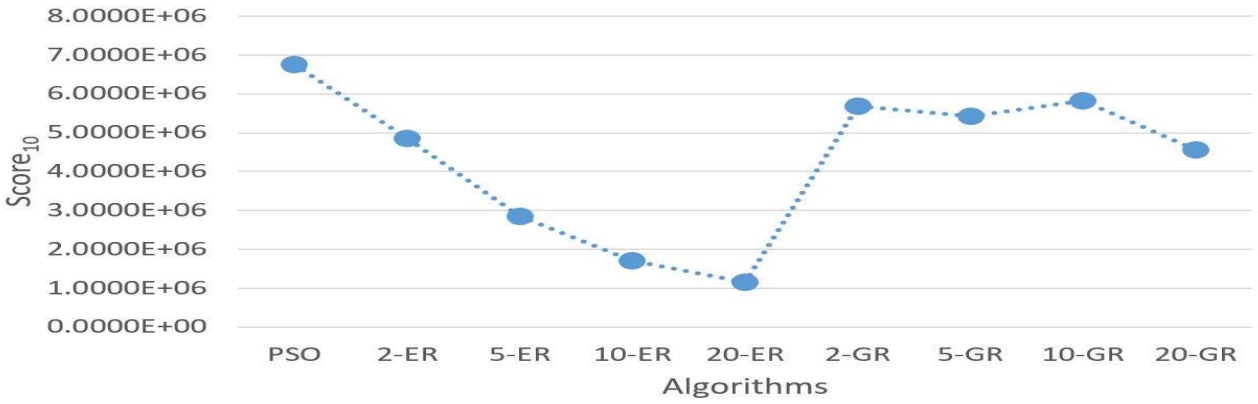
$$Hyb\_Score = \sum_{k=6}^{8} mean(f_k^a)|_{D=10} + \sum_{k=6}^{8} median(f_k^a)|_{D=10} + \sum_{k=6}^{8} mean(f_k^a)|_{D=30} + \sum_{k=6}^{8} median(f_k^a)|_{D=30} \tag{25}$$

$$Com\_Score = \sum_{k=9}^{15} mean(f_k^a)|_{D=10} + \sum_{k=9}^{15} median(f_k^a)|_{D=10} + \sum_{k=9}^{15} mean(f_k^a)|_{D=30} + \sum_{k=9}^{15} median(f_k^a)|_{D=30} \tag{26}$$

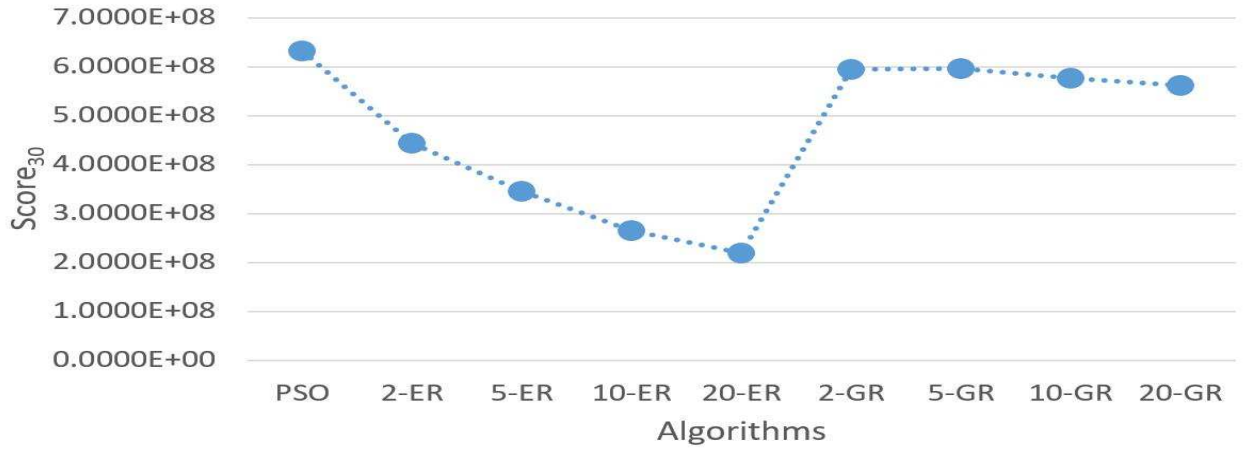
The Uni _Score, Sim _Score, Hyb _Score and Com _Score of PSO, 2 ER, 5 ER, 10 ER, 20 ER, 2 GR, 5 GR, 10 GR and 20 GR were shown in Table 3 and Figure 5. The results showed ER-FPSO had more efficience in the convergence performance than GR-FPSO at the unimodal and hybrid functions. To the simple mutimodal and composition functions, the performance was close to ER-FPSO and GR-FPSO.

The experimental results showed that the ER-FPSO or the GR-FPSO had a stronger ability to move into the global optima with higher convergence speed than the original algorithm [13]. At the same time, the results showed the 2 GR-FPSO was close to the 2 ER-FPSO in performance and the 20 ER-FPSO performed better than the 20 GR-FPSO.

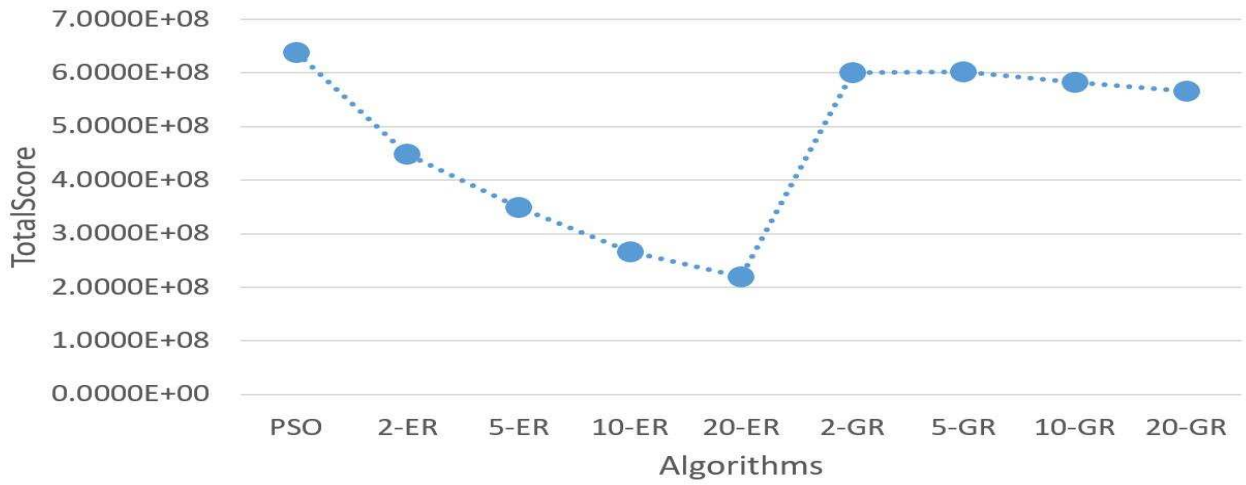
Note that when the population size was invariable, the number of family was inversely related to the number of family members. If the number of family was big, this meant the swarm had abundant diversity. If the number of the family members was big, this meant the family had abundant information sources. In experiments, the population size was 100. If every family had 20 particles, this swarm had 5 families; if every family had 2 particles, this swarm had 50 families. 50 families had more changes and diversities than 5 families. On the other hand, 20 particles have more information providers than 2 particles in every family. So, the experimental results illustrated that the diversity of the family was more important than that of the swarm to the ER-FPSO and the diversity of the family was close to that of the swarm to the GR-FPSO.



(a) $Score_{10}$

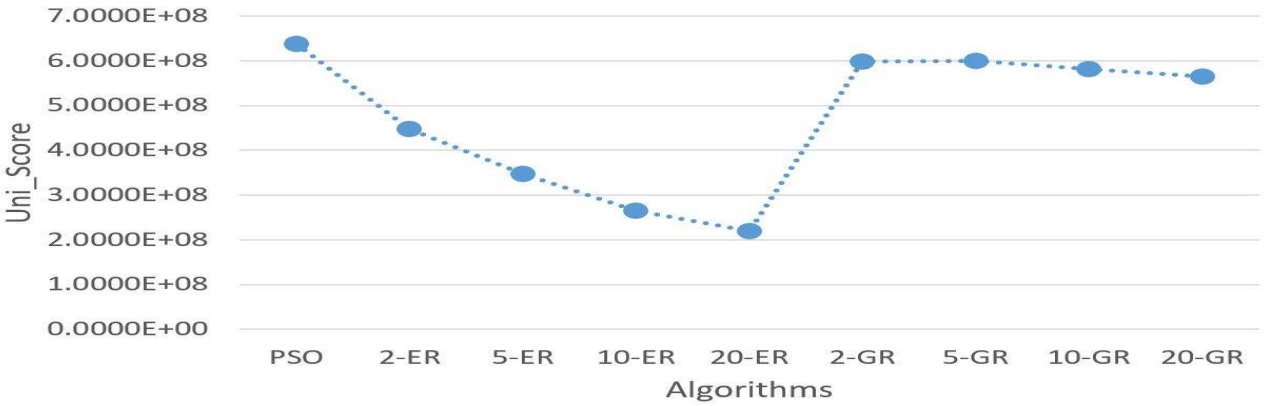


(b) $Score_{30}$

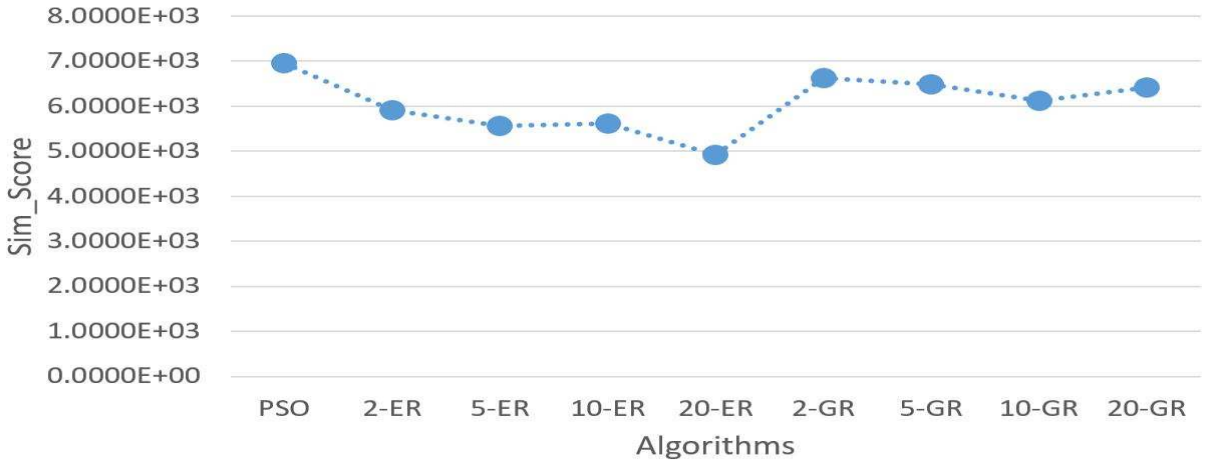


(c) $TotalScore$

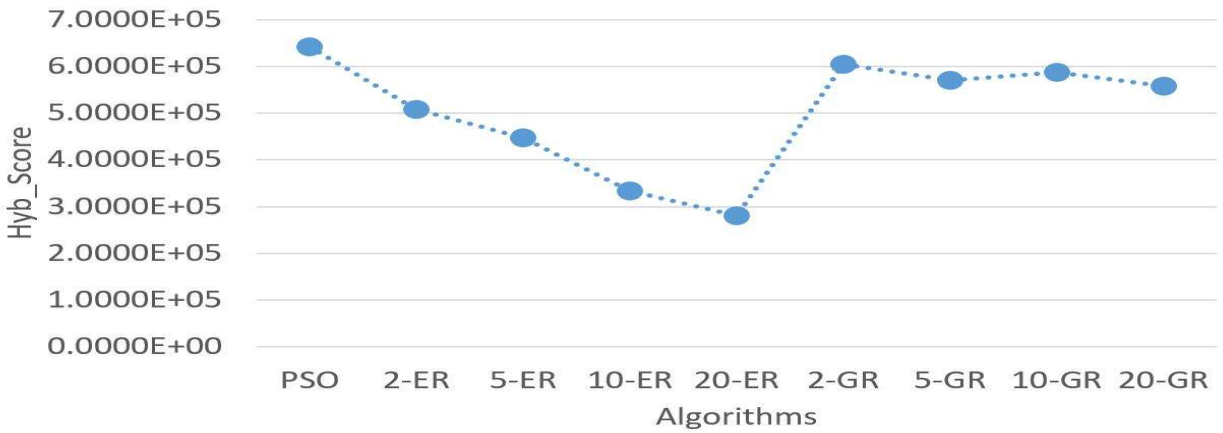
Fig.4: The Score10, Score30 and Total Score of different algorithms



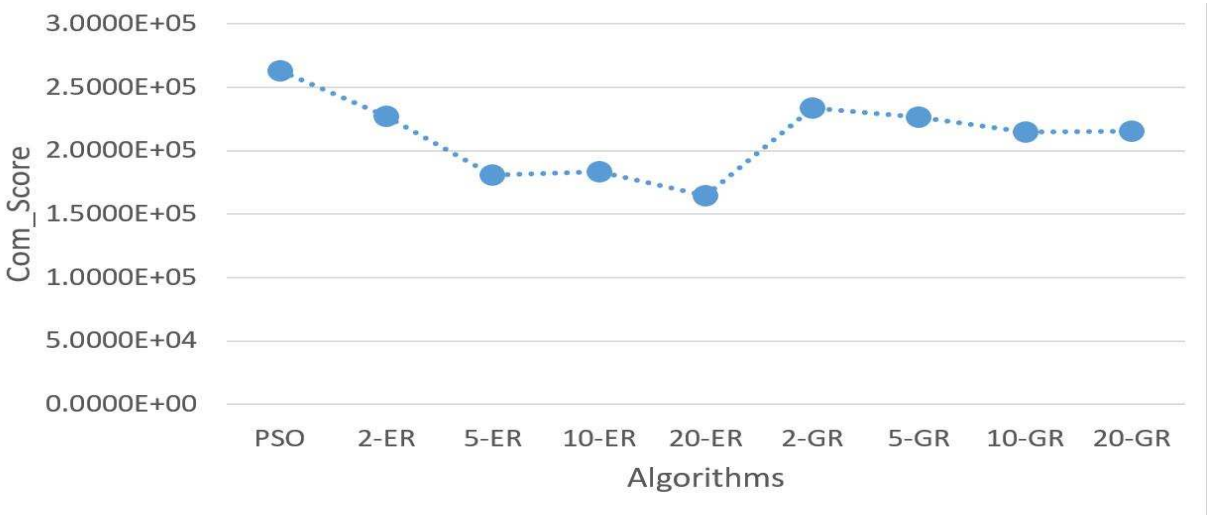
(a) *Uni_Score*



(b) *Sim_Score*



(c) *Hyb_Score*



(d) *Com_Score*

Fig.5: The Uni _Score, Sim _Score, Hyb Score and Com _Score of different algorithms

Table 2: The Score10, Score30 and Total Score of different algorithms

Algorithm	Score10	Score30	TotalScore
PSO	6.7604E+0	6.3218E+0	6.3894E+08
2 ER	4.8504E+0	4.4308E+0	4.4793E+08
5 ER	2.8420E+0	3.4562E+0	3.4846E+08
10 ER	1.7038E+0	2.6440E+0	2.6610E+08
20 ER	1.1560E+0	2.1834E+0	2.1950E+08
2 GR	5.6798E+0	5.9445E+0	6.0013E+08
5 GR	5.4257E+0	5.9623E+0	6.0165E+08
10 GR	5.8171E+0	5.7656E+0	5.8238E+08
20 GR	4.5620E+0	5.6173E+0	5.6629E+08

Table 3: The Uni _Score, Sim _Score, Hyb _Score and Com _Score of different algorithms

Algorithm	Uni Score	Sim Score	Hyb Score	Com Score
PSO	6.3803E+08	6.9547E+03	6.4097E+05	2.6292E+05
2 ER	4.4719E+08	5.9192E+03	5.0776E+05	2.2693E+05
5 ER	3.4783E+08	5.5598E+03	4.4708E+05	1.8093E+05
10 ER	2.6558E+08	5.6100E+03	3.3312E+05	1.8342E+05
20 ER	2.1905E+08	4.9201E+03	2.8007E+05	1.6469E+05
2 GR	5.9928E+08	6.6276E+03	6.0430E+05	2.3385E+05
5 GR	6.0085E+08	6.4909E+03	5.7047E+05	2.2652E+05
10 GR	5.8157E+08	6.1190E+03	5.8748E+05	2.1491E+05
20 GR	5.6551E+08	6.4097E+03	5.5776E+05	2.1524E+05

According to the above tables and figures, the experimental results showed that the traditional PSO was easy to be trapped into the local optimum solution owing to the lack of swarm's diversity. But, the FPSO had more searching choices for the particle swarm so that it was hard to be trapped into the local optimum. The results also demonstrated the effectiveness of considering family as a unit. Therefore, the FPSO was a more effective algorithm for solving optimization problems than PSO.

V. Conclusions

In the traditional PSO [13], particles are discrete and have no direct effects on each other. Different from the traditional PSO, we presented the FPSO method that improved the cognitive ability of individuals to return to environments where the family experienced the best performance. The constraint mechanism was introduced through as-signing particles in different families. In order to achieve the FPSO, we defined two types of

relationships between particles, i.e., the ER and the GR, in the proposed FPSO as the different structures of family communication strategies. Experimental results showed the advantage and the effectiveness of the proposed ER-FPSO and GR-FPSO methods.

The proposed ER-FPSO and GR-FPSO methods were also compared in the experiments. If the number of the family was big, the swarm had abundant diversity; if the number of the family members was big, the family had abundant information sources. The diversity of the family was more important than that of the swarm to the ER-FPSO and the diversity of the family was close to that of the swarm to the GR-FPSO. This kind of relation provided different choices to users to solve real problems. Especially, the GR-FPSO divided different particles into a parent particle and many child particles in a family. Since particles had multi-roles, the division of labor was introduced in a swarm and had much efficient convergence. In the future, we will study to use the multi-roles or division of labor for optimization techniques, and solve the relative issues in the actual applications of the proposed ER-FPSO and GR-FPSO methods.

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Appendix

Table 4: Results for 10D, PSO - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	1.7556E-01	1.4363E+03	6.3847E+01	1.6723E+02	2.7677E+02
f2	2.3370E-01	3.0003E+04	2.4807E+03	9.3273E+03	1.0122E+04
f3	5.6843E-14	2.0189E+01	2.0099E+01	1.8135E+01	6.0386E+00
f4	0.0000E+00	3.9798E+00	1.9899E+00	1.9509E+00	1.0522E+00
f5	1.2491E-01	3.8233E+02	6.8460E+01	9.1332E+01	8.2747E+01
f6	2.7374E+00	3.1226E+02	1.2197E+02	1.0396E+02	7.5294E+01
f7	0.0000E+00	1.9702E+00	3.6544E-02	4.6450E-01	5.9476E-01
f8	4.4400E-03	1.4321E+02	8.1835E-01	2.6866E+01	4.3550E+01
f9	1.0002E+02	1.0010E+02	1.0005E+02	1.0005E+02	1.7154E-02
f10	2.1658E+02	3.5426E+02	2.1954E+02	2.5270E+02	4.6626E+01
f11	6.3000E-02	3.0040E+02	3.0012E+02	2.1781E+02	1.3524E+02
f12	1.0037E+02	1.0178E+02	1.0105E+02	1.0109E+02	2.9577E-01
f13	1.9691E+01	2.8189E+01	2.4366E+01	2.4512E+01	2.2691E+00
f14	1.0000E+02	9.9751E+03	2.9436E+03	3.4793E+03	3.1225E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.3924E-13

Table 5: Results for 10D, 2 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	1.5224E-02	9.2833E+02	1.6593E+01	6.6241E+01	1.6225E+02
f2	7.0338E-01	2.7864E+04	1.0236E+04	9.7078E+03	8.5063E+03
f3	0.0000E+00	2.0173E+01	2.0031E+01	1.8478E+01	5.4445E+00
f4	0.0000E+00	5.9698E+00	1.9899E+00	2.2240E+00	1.1703E+00
f5	1.8736E-01	4.7879E+02	1.3255E+02	1.3201E+02	9.9474E+01
f6	2.0900E-01	7.4643E+02	1.2102E+02	1.1206E+02	1.2292E+02
f7	0.0000E+00	1.0165E+00	8.4164E-02	3.6224E-01	4.5489E-01
f8	5.0373E-03	1.2519E+02	7.4191E-01	2.1280E+01	3.7534E+01
f9	1.0002E+02	1.0009E+02	1.0004E+02	1.0005E+02	1.5758E-02
f10	2.1660E+02	3.5009E+02	2.2036E+02	2.4807E+02	4.1210E+01
f11	9.2513E-02	3.0048E+02	3.0014E+02	2.4724E+02	1.1552E+02
f12	1.0046E+02	1.0206E+02	1.0121E+02	1.0119E+02	3.5004E-01
f13	2.0857E+01	2.7645E+01	2.4671E+01	2.4453E+01	2.1926E+00
f14	1.0000E+02	1.0096E+04	2.9471E+03	3.7972E+03	3.0665E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	0.0000E+00

Table 6: Results for 10D, 5 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	9.4946E-05	5.3334E+02	4.2219E-01	2.4322E+01	8.8251E+01
f2	7.8869E+00	2.2378E+04	4.3484E+03	7.6787E+03	7.8603E+03
f3	0.0000E+00	2.0115E+01	2.0000E+01	1.9227E+01	3.9232E+00
f4	0.0000E+00	6.9647E+00	2.9849E+00	2.7313E+00	1.3907E+00
f5	3.6023E+00	4.0219E+02	1.3407E+02	1.3129E+02	1.1190E+02
f6	1.0449E+00	3.0175E+02	1.2194E+02	1.0218E+02	8.2505E+01
f7	0.0000E+00	1.9034E+00	1.1375E-01	5.9023E-01	6.0343E-01
f8	1.1088E-06	1.4306E+02	7.7356E-01	2.7508E+01	4.5876E+01
f9	1.0001E+02	1.0010E+02	1.0004E+02	1.0004E+02	1.8538E-02
f10	2.1694E+02	3.5056E+02	2.2054E+02	2.4152E+02	3.8792E+01
f11	4.9457E-02	4.0000E+02	3.0012E+02	2.0214E+02	1.4493E+02
f12	1.0033E+02	1.0192E+02	1.0091E+02	1.0102E+02	3.4809E-01
f13	2.0617E+01	2.8630E+01	2.4680E+01	2.4929E+01	2.3355E+00
f14	1.0000E+02	9.9261E+03	2.9461E+03	3.6685E+03	2.7101E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	0.0000E+00

Table 7: Results for 10D, 10 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	2.1087E-07	1.7507E+01	1.9167E-03	6.2183E-01	2.6483E+00
f2	3.1994E-01	3.2441E+04	1.2485E+03	5.3274E+03	7.3967E+03
f3	0.0000E+00	2.0107E+01	2.0000E+01	1.8438E+01	5.4325E+00
f4	0.0000E+00	6.9647E+00	2.9849E+00	3.3165E+00	1.4024E+00
f5	6.8924E+00	4.7517E+02	1.4407E+02	1.5523E+02	1.0573E+02
f6	1.2032E+00	9.9932E+02	1.2362E+02	1.4755E+02	1.6483E+02
f7	0.0000E+00	1.9204E+00	8.4313E-02	5.4684E-01	5.8182E-01
f8	5.3538E-05	1.4307E+02	1.6757E+01	3.0333E+01	4.6740E+01
f9	1.0001E+02	1.0009E+02	1.0005E+02	1.0005E+02	2.0263E-02
f10	1.9657E+02	3.3146E+02	2.2025E+02	2.4226E+02	3.4626E+01
f11	4.9353E-02	4.0000E+02	3.0023E+02	2.4926E+02	1.1731E+02
f12	1.0059E+02	1.0174E+02	1.0109E+02	1.0110E+02	2.9752E-01
f13	2.0208E+01	2.9571E+01	2.5556E+01	2.5250E+01	2.3447E+00
f14	3.0000E+02	1.0033E+04	2.9472E+03	3.5874E+03	2.8813E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	0.0000E+00

Table 8: Results for 10D, 20 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	6.4801E-11	3.0844E+01	2.9741E-05	7.2212E-01	4.3427E+00
f2	7.0666E-03	2.1663E+04	5.5121E+02	4.5950E+03	6.0883E+03
f3	0.0000E+00	2.0109E+01	2.0000E+01	1.9220E+01	3.9218E+00
f4	9.9496E-01	6.9647E+00	3.9798E+00	3.9798E+00	1.5285E+00
f5	3.7897E+00	4.8545E+02	1.4196E+02	1.5467E+02	1.1100E+02
f6	4.1649E-01	2.7804E+02	1.2194E+02	1.2722E+02	8.5356E+01
f7	1.1369E-13	1.0381E+00	9.9705E-01	5.5676E-01	4.8422E-01
f8	1.1428E-03	1.7681E+02	1.6764E+01	2.8102E+01	4.9626E+01
f9	1.0001E+02	1.0012E+02	1.0005E+02	1.0005E+02	2.1388E-02
f10	2.0504E+02	3.5026E+02	2.2147E+02	2.4870E+02	3.9418E+01
f11	4.3603E-02	3.0058E+02	3.0027E+02	2.4736E+02	1.1555E+02
f12	1.0057E+02	1.0191E+02	1.0099E+02	1.0106E+02	3.0331E-01
f13	2.0888E+01	3.1001E+01	2.6300E+01	2.5831E+01	2.1780E+00
f14	1.0000E+02	1.0101E+04	2.9805E+03	4.2527E+03	3.0623E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	5.5695E-14

Table 9: Results for 10D, 2 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	1.2988E-06	9.1886E+02	3.2307E+01	1.7493E+02	2.6076E+02
f2	1.6850E+00	2.9183E+04	2.5873E+03	8.8482E+03	1.0105E+04
f3	0.0000E+00	2.0169E+01	2.0065E+01	1.7711E+01	6.5315E+00
f4	0.0000E+00	4.9748E+00	1.9899E+00	2.3801E+00	1.1270E+00
f5	2.4982E-01	4.3258E+02	1.3710E+02	1.3357E+02	1.1777E+02
f6	1.4214E+00	4.8299E+02	1.2421E+02	1.2782E+02	1.0510E+02
f7	0.0000E+00	1.9225E+00	3.6544E-02	3.9602E-01	5.1317E-01
f8	6.9705E-02	1.2504E+02	6.4517E-01	2.4324E+01	4.2521E+01
f9	1.0001E+02	1.0011E+02	1.0005E+02	1.0005E+02	1.9251E-02
f10	1.0000E+02	3.5291E+02	2.1991E+02	2.4049E+02	4.4416E+01
f11	4.5626E-02	3.0048E+02	3.0011E+02	2.1781E+02	1.3524E+02
f12	1.0029E+02	1.0190E+02	1.0108E+02	1.0112E+02	3.5116E-01
f13	2.1436E+01	2.8773E+01	2.4470E+01	2.4719E+01	1.8363E+00
f14	1.0000E+02	1.0007E+04	2.9686E+03	3.5394E+03	3.1218E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	6.1846E-14

Table 10: Results for 10D, 5 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	3.3988E-01	5.9082E+02	1.8917E+01	8.0664E+01	1.3045E+02
f2	3.4561E-01	2.7456E+04	1.8944E+03	6.8349E+03	8.7979E+03
f3	0.0000E+00	2.0160E+01	2.0038E+01	1.9263E+01	3.9306E+00
f4	0.0000E+00	5.9698E+00	1.9899E+00	2.3021E+00	1.4140E+00
f5	3.5399E+00	4.2982E+02	1.2210E+02	1.2693E+02	1.1050E+02
f6	1.2033E+00	2.6886E+02	1.2535E+02	1.2304E+02	7.6074E+01
f7	0.0000E+00	1.9291E+00	7.4448E-02	4.9166E-01	5.3142E-01
f8	8.5214E-05	1.4307E+02	6.2856E-01	1.9591E+01	4.0956E+01
f9	1.0002E+02	1.0009E+02	1.0005E+02	1.0005E+02	1.7261E-02
f10	2.1693E+02	3.3220E+02	2.1975E+02	2.3726E+02	3.2518E+01
f11	2.9347E-02	3.0056E+02	3.0010E+02	1.8840E+02	1.4653E+02
f12	1.0040E+02	1.0196E+02	1.0106E+02	1.0110E+02	3.0482E-01
f13	2.0339E+01	2.8627E+01	2.5044E+01	2.5140E+01	2.0773E+00
f14	1.0000E+02	9.9908E+03	4.0000E+02	2.7913E+03	3.1516E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.1738E-13

Table 11: Results for 10D, 10 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	7.1085E-02	5.0406E+02	3.5960E+01	6.8299E+01	9.1898E+01
f2	3.4494E+00	2.8698E+04	1.7280E+03	6.6264E+03	8.3078E+03
f3	0.0000E+00	2.0134E+01	2.0021E+01	1.9645E+01	2.8062E+00
f4	0.0000E+00	4.9748E+00	1.9899E+00	2.2240E+00	1.0824E+00
f5	3.5399E+00	4.3134E+02	3.6886E+01	9.6044E+01	1.1417E+02
f6	1.0669E+00	2.8048E+02	1.2188E+02	1.1978E+02	8.8766E+01
f7	0.0000E+00	1.9132E+00	8.4164E-02	4.8738E-01	5.5592E-01
f8	8.9958E-04	1.4309E+02	6.1012E-01	2.4085E+01	4.5565E+01
f9	1.0002E+02	1.0008E+02	1.0005E+02	1.0005E+02	1.5329E-02
f10	1.0000E+02	3.3098E+02	2.1959E+02	2.3561E+02	3.8532E+01
f11	5.4555E-02	3.0038E+02	3.0013E+02	2.4721E+02	1.1553E+02
f12	1.0049E+02	1.0170E+02	1.0100E+02	1.0103E+02	2.8330E-01
f13	2.0122E+01	2.9387E+01	2.4509E+01	2.4481E+01	2.0745E+00
f14	1.0000E+02	9.9520E+03	2.9715E+03	3.9429E+03	2.7935E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.3540E-13

Table 12: Results for 10D, 20 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	9.2852E-02	5.5959E+02	3.1096E+01	1.0173E+02	1.4422E+02
f2	4.9020E-05	2.9148E+04	1.3936E+03	6.0380E+03	8.0101E+03
f3	5.6843E-14	2.0184E+01	2.0037E+01	1.8478E+01	5.4445E+00
f4	0.0000E+00	3.9798E+00	1.9899E+00	1.8924E+00	1.1125E+00
f5	3.6023E+00	3.7859E+02	1.3743E+02	1.3685E+02	1.1238E+02
f6	1.3750E+00	3.1172E+02	1.2660E+02	1.2626E+02	9.4907E+01
f7	0.0000E+00	1.9691E+00	2.1293E-01	5.6565E-01	5.9169E-01
f8	6.0703E-03	1.4307E+02	6.5523E-01	2.3744E+01	4.3226E+01
f9	1.0002E+02	1.0010E+02	1.0004E+02	1.0005E+02	1.6731E-02
f10	2.1671E+02	3.5341E+02	2.2028E+02	2.4726E+02	4.3424E+01
f11	6.0968E-02	3.0060E+02	3.0013E+02	2.2370E+02	1.3207E+02
f12	1.0063E+02	1.0175E+02	1.0113E+02	1.0114E+02	2.6300E-01
f13	2.0283E+01	2.8354E+01	2.5623E+01	2.5222E+01	2.1886E+00
f14	1.0000E+02	1.0026E+04	2.9686E+03	3.9051E+03	3.0031E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.4373E-13

Table 13: Results for 30D, PSO - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f_1	1.5641E+04	2.7148E+06	1.1998E+05	4.7924E+05	6.7146E+05
f_2	2.7020E-01	1.3862E+04	5.6495E+03	5.8983E+03	3.7959E+03
f_3	2.0393E+01	2.0813E+01	2.0672E+01	2.0664E+01	9.5187E-02
f_4	2.3879E+01	5.6713E+01	4.1788E+01	4.1437E+01	8.5839E+00
f_5	5.1602E+02	3.2016E+03	2.0137E+03	1.8934E+03	6.0981E+02
f_6	1.3700E+03	2.1968E+05	2.3696E+04	3.4849E+04	3.8323E+04
f_7	3.6238E+00	9.8258E+00	5.5585E+00	5.7530E+00	1.2171E+00
f_8	9.6680E+02	5.7404E+04	1.9385E+04	2.1978E+04	1.4263E+04
f_9	1.0022E+02	2.5469E+02	1.0197E+02	1.1314E+02	3.9091E+01
f_{10}	1.6170E+03	6.2625E+04	2.1122E+04	2.4038E+04	1.7966E+04
f_{11}	3.0194E+02	7.3578E+02	5.9475E+02	5.6204E+02	1.3538E+02
f_{12}	1.0321E+02	1.0652E+02	1.0477E+02	1.0477E+02	6.6102E-01
f_{13}	8.1365E+01	1.1404E+02	9.4066E+01	9.4389E+01	5.8533E+00
f_{14}	3.1353E+04	3.6422E+04	3.4000E+04	3.3609E+04	1.5491E+03
f_{15}	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.2323E-13

Table 14: Results for 30D, 2 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f_1	6.2742E+02	2.0367E+06	1.9541E+04	2.7274E+05	5.3971E+05
f_2	8.1006E-01	1.4867E+04	4.1874E+03	6.0274E+03	4.8060E+03
f_3	2.0190E+01	2.0806E+01	2.0527E+01	2.0506E+01	1.7599E-01
f_4	2.2884E+01	7.7236E+01	4.3778E+01	4.5136E+01	1.2270E+01
f_5	5.0847E+02	3.0810E+03	1.6783E+03	1.7490E+03	5.3810E+02
f_6	1.4323E+03	8.2293E+04	7.4896E+03	1.3426E+04	1.4762E+04
f_7	3.3545E+00	1.0700E+01	5.6680E+00	6.2393E+00	2.0599E+00
f_8	4.2317E+02	3.7972E+04	9.6226E+03	1.3097E+04	1.1851E+04
f_9	1.0013E+02	2.3805E+02	1.0188E+02	1.0436E+02	1.9103E+01
f_{10}	1.3547E+03	7.8892E+04	2.0277E+04	2.4128E+04	1.7640E+04
f_{11}	3.0226E+02	7.6479E+02	6.0998E+02	5.6983E+02	1.2179E+02
f_{12}	1.0373E+02	1.0580E+02	1.0467E+02	1.0474E+02	5.1772E-01
f_{13}	7.1370E+01	1.1146E+02	9.3989E+01	9.3908E+01	7.5437E+00
f_{14}	3.1386E+04	3.5873E+04	3.3969E+04	3.3531E+04	1.3490E+03
f_{15}	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.4648E-13

Table 15: Results for 30D, 5 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f_1	6.5863E+02	3.7280E+06	1.9218E+04	4.8412E+05	8.3049E+05
f_2	1.5404E+00	1.4942E+04	4.8255E+03	5.3989E+03	3.7948E+03
f_3	2.0001E+01	2.0759E+01	2.0145E+01	2.0250E+01	2.3101E-01
f_4	2.3879E+01	7.7607E+01	4.2783E+01	4.3739E+01	1.0662E+01
f_5	5.2320E+02	3.2624E+03	1.8587E+03	1.8672E+03	5.6826E+02
f_6	4.3024E+02	2.3143E+05	6.1728E+03	2.2926E+04	4.2638E+04
f_7	3.3345E+00	1.0621E+01	5.7687E+00	6.0614E+00	1.5877E+00
f_8	2.9086E+02	4.3471E+04	9.6547E+03	1.0548E+04	8.6256E+03
f_9	1.0015E+02	2.4502E+02	1.0188E+02	1.0459E+02	2.0064E+01
f_{10}	1.6180E+03	5.2649E+04	1.7321E+04	2.0174E+04	1.3997E+04
f_{11}	3.0161E+02	7.7963E+02	5.9251E+02	5.9668E+02	9.3085E+01
f_{12}	1.0273E+02	1.0566E+02	1.0465E+02	1.0464E+02	5.7683E-01
f_{13}	7.9047E+01	1.0989E+02	9.5294E+01	9.5513E+01	6.6195E+00
f_{14}	3.1384E+04	3.6164E+04	3.4124E+04	3.3596E+04	1.4314E+03
f_{15}	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.2105E-13

Table 16: Results for 30D, 10 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	1.5180E+02	2.6913E+06	6.8910E+03	2.5062E+05	5.3067E+05
f2	4.1630E+00	1.3982E+04	5.5972E+03	5.5429E+03	3.9605E+03
f3	2.0000E+01	2.0789E+01	2.0024E+01	2.0133E+01	2.2970E-01
f4	2.0894E+01	7.5617E+01	4.3778E+01	4.3739E+01	1.1747E+01
f5	8.2287E+02	2.9924E+03	2.0271E+03	1.9647E+03	4.7394E+02
f6	5.5967E+02	1.6011E+05	5.0625E+03	1.4702E+04	3.0829E+04
f7	3.6484E+00	1.1454E+01	5.7668E+00	6.0302E+00	1.7265E+00
f8	4.8014E+02	4.3631E+04	5.2225E+03	8.3407E+03	9.9330E+03
f9	1.0015E+02	2.5875E+02	1.0188E+02	1.0472E+02	2.2008E+01
f10	1.7649E+03	6.3635E+04	2.5081E+04	2.5452E+04	1.7647E+04
f11	3.0364E+02	7.5760E+02	6.0547E+02	6.0408E+02	9.2910E+01
f12	1.0327E+02	1.0579E+02	1.0464E+02	1.0467E+02	6.2406E-01
f13	8.1717E+01	1.1063E+02	9.6217E+01	9.5401E+01	7.1686E+00
f14	3.1394E+04	3.6052E+04	3.4233E+04	3.3634E+04	1.6270E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.6132E-13

Table 17: Results for 30D, 20 ER - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	7.2433E+00	3.1475E+06	2.8623E+02	4.8298E+05	8.3533E+05
f2	2.9025E+00	1.2875E+04	4.5182E+03	4.9148E+03	3.0779E+03
f3	2.0000E+01	2.0687E+01	2.0000E+01	2.0047E+01	1.4693E-01
f4	2.2884E+01	7.7607E+01	4.6763E+01	4.6801E+01	1.1131E+01
f5	6.2519E+02	2.7236E+03	1.7295E+03	1.6578E+03	5.2555E+02
f6	6.7353E+02	3.1327E+05	4.2570E+03	1.4710E+04	4.6553E+04
f7	3.6826E+00	1.1580E+01	6.1408E+00	6.5964E+00	1.8040E+00
f8	1.2133E+02	5.2807E+04	3.9087E+03	8.9140E+03	1.1996E+04
f9	1.0059E+02	2.4579E+02	1.0195E+02	1.0996E+02	3.2612E+01
f10	2.2612E+03	5.2507E+04	1.9107E+04	2.0254E+04	1.4115E+04
f11	3.0267E+02	7.3546E+02	5.9294E+02	5.7965E+02	1.1100E+02
f12	1.0323E+02	1.0599E+02	1.0463E+02	1.0464E+02	6.4182E-01
f13	7.5818E+01	1.1478E+02	9.5609E+01	9.5411E+01	7.4861E+00
f14	3.1422E+04	3.6294E+04	3.4418E+04	3.3772E+04	1.6070E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.3456E-13

Table 18: Results for 30D, 2 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f1	3.6616E+03	3.0315E+06	7.9218E+04	4.2641E+05	6.9339E+05
f2	5.6031E-01	1.3492E+04	5.0213E+03	4.7398E+03	3.6957E+03
f3	2.0056E+01	2.0837E+01	2.0598E+01	2.0584E+01	1.4595E-01
f4	1.9899E+01	7.5617E+01	4.3778E+01	4.4890E+01	1.3149E+01
f5	7.6476E+02	3.2421E+03	1.8142E+03	1.8509E+03	4.6398E+02
f6	1.2007E+03	1.1729E+05	1.7007E+04	2.4276E+04	2.6564E+04
f7	2.3306E+00	9.8647E+00	5.9538E+00	5.7870E+00	1.6292E+00
f8	5.3971E+02	4.6930E+04	2.2006E+04	2.0916E+04	1.1614E+04
f9	1.0016E+02	2.5546E+02	1.0205E+02	1.1308E+02	3.8797E+01
f10	1.2036E+03	5.3847E+04	1.6897E+04	2.0873E+04	1.6491E+04
f11	3.0165E+02	7.3409E+02	5.8872E+02	5.7201E+02	1.1563E+02
f12	1.0358E+02	1.0611E+02	1.0477E+02	1.0482E+02	5.3948E-01
f13	7.8551E+01	1.0540E+02	9.2464E+01	9.2051E+01	6.1954E+00
f14	3.1420E+04	3.5877E+04	3.4117E+04	3.3750E+04	1.2741E+03
f15	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.1333E-13

Table 19: Results for 30D, 5 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f_1	2.0936E+03	5.8677E+06	3.8083E+04	4.7920E+05	1.0056E+06
f_2	1.6423E+02	1.3607E+04	6.3889E+03	5.6127E+03	3.8307E+03
f_3	2.0132E+01	2.0802E+01	2.0551E+01	2.0529E+01	1.6238E-01
f_4	2.0894E+01	7.5617E+01	4.1788E+01	4.3447E+01	1.2210E+01
f_5	7.4418E+02	2.6419E+03	1.8050E+03	1.7982E+03	4.8078E+02
f_6	1.0690E+03	2.1713E+05	1.0735E+04	2.2280E+04	3.3372E+04
f_7	3.3998E+00	1.0327E+01	5.6282E+00	5.8036E+00	1.6172E+00
f_8	1.0654E+03	3.9810E+04	1.5585E+04	1.5765E+04	1.0384E+04
f_9	1.0023E+02	2.3824E+02	1.0193E+02	1.0451E+02	1.9107E+01
f_{10}	1.5408E+03	7.7974E+04	2.3480E+04	2.5445E+04	1.9028E+04
f_{11}	3.0246E+02	7.1923E+02	5.7064E+02	5.4524E+02	1.1879E+02
f_{12}	1.0330E+02	1.0614E+02	1.0444E+02	1.0465E+02	6.7729E-01
f_{13}	8.2403E+01	1.1107E+02	9.4632E+01	9.4570E+01	6.7549E+00
f_{14}	3.1358E+04	3.5976E+04	3.4152E+04	3.3606E+04	1.4980E+03
f_{15}	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.5561E-13

Table 20: Results for 30D, 10 GR - Learning-based Problems

Function	Best	Worst	Median	Mean	Std.
f_1	2.9781E+03	2.9317E+06	6.1059E+04	3.6050E+05	6.5432E+05
f_2	2.0758E+01	1.4242E+04	4.0597E+03	4.4926E+03	3.5721E+03
f_3	2.0099E+01	2.0787E+01	2.0607E+01	2.0551E+01	1.7156E-01
f_4	2.3879E+01	6.6662E+01	4.5768E+01	4.3856E+01	9.7645E+00
f_5	7.1044E+02	2.7706E+03	1.6252E+03	1.6664E+03	4.9028E+02
f_6	1.4688E+03	2.7003E+05	1.4397E+04	2.8639E+04	4.5074E+04
f_7	3.0539E+00	1.2842E+01	5.6940E+00	6.1621E+00	1.9447E+00
f_8	1.9253E+02	7.9023E+04	1.0216E+04	1.3981E+04	1.4478E+04
f_9	1.0007E+02	2.5145E+02	1.0198E+02	1.1258E+02	3.7197E+01
f_{10}	1.2805E+03	8.9136E+04	1.7417E+04	1.9871E+04	1.7870E+04
f_{11}	3.0315E+02	7.6836E+02	6.0372E+02	5.9039E+02	1.0258E+02
f_{12}	1.0361E+02	1.0676E+02	1.0492E+02	1.0488E+02	6.6238E-01
f_{13}	7.4781E+01	1.0770E+02	9.3293E+01	9.3082E+01	6.8229E+00
f_{14}	3.1403E+04	3.5745E+04	3.3965E+04	3.3378E+04	1.3654E+03
f_{15}	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.5055E-13

Table 21: Results for 30D, 20 GR - Learning-based Problems

Functio	Best	Worst	Median	Mean	Std.
f_1	2.0307E+03	2.0501E+06	4.8376E+04	3.4275E+05	5.5615E+05
f_2	2.8690E+00	1.3162E+04	5.8404E+03	5.7173E+03	3.5432E+03
f_3	2.0177E+01	2.0775E+01	2.0535E+01	2.0515E+01	1.5479E-01
f_4	2.1889E+01	6.3677E+01	4.1788E+01	4.1905E+01	1.0200E+01
f_5	7.3528E+02	3.4100E+03	1.6986E+03	1.7574E+03	5.7929E+02
f_6	1.0712E+03	1.7353E+05	1.4107E+04	2.5428E+04	3.3902E+04
f_7	3.6346E+00	9.5809E+00	5.7003E+00	5.7913E+00	1.3423E+00
f_8	6.6011E+02	5.9740E+04	1.8025E+04	1.8731E+04	1.3879E+04
f_9	1.0015E+02	2.6945E+02	1.0200E+02	1.1577E+02	4.2753E+01
f_{10}	1.4962E+03	5.7893E+04	1.6725E+04	2.0603E+04	1.7054E+04
f_{11}	3.0164E+02	7.4017E+02	6.2923E+02	5.9799E+02	1.0724E+02
f_{12}	1.0336E+02	1.0602E+02	1.0483E+02	1.0480E+02	6.5942E-01
f_{13}	8.2107E+01	1.1239E+02	9.4376E+01	9.4721E+01	6.8193E+00
f_{14}	3.1454E+04	3.5972E+04	3.4037E+04	3.3867E+04	1.2967E+03
f_{15}	1.0000E+02	1.0000E+02	1.0000E+02	1.0000E+02	1.3659E-13

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The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

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The author fees of such paper may be waived off up to 40%.

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The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

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After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

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30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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