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## Table of Contents

A STUDY OF THE INFLUENCE OF WORK BASED LEARNING (WBL) PLACEMENT ON ACADEMIC PERFORMANCE OF COMPUTER SCIENCE AND INFORMATION SYSTEMS STUDENTS	7
Utilization of Arts in Social Work Practice: A Review of the Literature	19
The status and Socioeconomic value of Cherry laurel ( <i>Prunus laurocerasus</i> L.): Advancement for the future	40
The Face of Technological Entrepreneurship	50
The Subjective Comfort Ratings of Customized Handles	63
Building Thermal Environment and User Adaptation in a Meditation Retreat in Khon Kaen, Thailand	72
Classification of Moving Objects in Surveillance Video	87
A Petri Net Model of Internal Organs Including Triple Energizer	97
Prevalence and Correlates of Non-Suicidal Self-Harm, Suicidal Ideation and Suicidal Behaviour in a Sample of Kenyan University Students	112

## **A STUDY OF THE INFLUENCE OF WORK BASED LEARNING (WBL) PLACEMENT ON ACADEMIC PERFORMANCE OF COMPUTER SCIENCE AND INFORMATION SYSTEMS STUDENTS**

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### **Abstract**

The computing programmes in almost all Universities faced criticism in terms of their coverage especially about meeting the needs of industry. Many employers complained that the programmes of study do not teach and what is required in the industry. The problem is not uncommon to the computing programmes offered by the University of Mauritius (UoM). There has been a strong move by the UoM to integrate WBL placement in the programme of studies to address the skills mismatch problem meeting the changes experienced in the employment patterns which make Computer Science and Information Systems graduates' skills highly valued. WBL placement was incorporated as sandwich programme organised over full-time work experience which involves full-time learning at work settings. WBL placement has been identified as a means of responding to the needs of employers making students fit for purpose and practice. Employers recruiting Computer Science and Information Systems students view WBL as vital in developing students into professional workers. While research confirmed that the WBL placement enhances employability of Computer Science and Information Systems graduates, its impact on academic performance of students is still being much questioned today. Some studies expressed that there is a causal link between improvement in academic achievement after the completion of an integrated WBL placement, others did not find much correlation between the two entities. Most studies carried out so far have based their investigation on anecdotal evidences or on sample which are rather small involving students from only a single field of study. This paper aims to examine the relationship between the two entities, placement and academic achievement, based on a concrete sample of undergraduate students studying from two fields Computer Science and Information Systems and who have experienced similar WBL placement. A comparative statistical analysis was carried out on students who did or did not undertake a WBL placement, their class of degree achieved was investigated. Secondary data was used where the degree classification obtained at the end of studies were analysed from four cohort of students graduating after three years of full-time study. The results revealed that there is a significant difference in academic performance of WBL students compared to those who have not undertaken WBL placement during their studies. It was found that students who undertook the WBL training graduated with better degree classifications. The paper concludes that work placement has a positive influence on the academic performance of students in the Computer Science and Information Systems fields.

**Keywords:** skills, work experience, academic achievement, training

## 1. Introduction

Computer Science degrees are among one of the fastest growing fields offering students with various opportunities to secure employment immediately after graduation. Yet, employers complain that there is mismatch between the academia and the needs of the industry. Many Universities offering degrees in Computer Science and Information Systems focus on the elements of programming as major and core subjects where students spent time learning to program on several platforms. Yet the practice of programming on campuses is found to be inadequate. [1] explained this situation as the “expectation gap” referring to the difference between what is considered important skills by the industry and those taught in academia. [2] expressed more severe criticism pointing out that the examples given in Computer Science courses do not resemble to what is practiced in the industry at all. [3] on his side called it the “skill gap” and stressed particularly on the absence of teaching important skills needed for work in the IT industry. There is need for students to step in the world of work experiencing real world situation to grasp further knowledge for making them fit for purpose and practice. To bridge the gap between the academia and the world of work, UoM offered its Computer Science and Information Systems students the possibility of undertaking WBL practice at the end of each year of study where students spend short period of training (two months) to acquire additional knowledge and skills from real work situation. WBL encompasses learning which links-specific experience in the workplace with the computer science course content provided by UoM. This involves the acquisition of knowledge, skills and attributes for the development of much needed core competencies for Computer Science and Information Systems students at the undergraduate level. WBL placement provides a vehicle for the transformation of knowledge through its use in a real-life setting [4]. The correlation between WBL training and employability of Computer Science graduates is quite comprehensive as regards to benefits [5], [6]. But there exist a dearth of literature about the correlation of WBL and academic achievement. It is still questionable whether the transferable skills developed on work practice, feed back to academic study and contribute towards better performance.

## 2. Literature review

[7] sought to investigate how placement affects academic performance and employment rates. They found that placements were more likely to be successful where universities consistently encouraged students to reflect on their learning and achievement. They did not give clear evidences as to whether WBL placement influences academic performance. Studies have also been carried out involving other fields of study, for instance [8] conducted a study where he analysed the examination results related to two cohorts of business undergraduates. He found no significant difference between those who undertook a placement and those who did not take a placement. [9] anecdotally found that “*students on their optional bioscience sandwich degrees benefit academically from*



*placement experience*”, but there was inadequate supportive evidence of this in the literature. They used multiple regression analysis to confirm that students taking a sandwich placement have a slightly better academic performance in their final year with an average of 4% more as compared to students without any placement.

On the other hand, [10] made a comprehensive study of students from the field of economics at the University of Surrey and provided evidence that completing a placement significantly increased the opportunities of obtaining a better degree classification. However, he used working variables that might otherwise reduce the belief about such correlation. He based himself on factors such as A-level subject choice and nationality, which did not reflect current status of the students while they were studying at university. His study did not attempt to explore other variables that would contribute to the increase in performance.

[11] on his side found out that there was little connection between placement experience and the academic performance. However, [12] added to the research on the effect of placements on academic performance. The majority of undergraduates in their study reported that their intellectual and personal development have improved through placement and that their level of confidence and motivation have been enhanced to continue their studies with more serenity. However, there was no further evidence that the enhanced confidence and motivation led to brighter academic performance as output.

[13] studied the academic performance of engineering students over three years and concluded that there was a causal link between placements and improved academic performance. However, he himself addressed the limitation of his study by explaining that the sample size he used was too small. In fact, he compared 40 students who have undertaken a placement with 40 others who have not undertaken any kind of placement. [14] agreed that completing a full year on WBL practice improved the degree classification, but clearly mentioned that it was not the placement year, which led to a better degree, rather it was the previous academic performance.

[15] conducted a study based on a sample of students who have completed their degree in Business Administration. They used an estimation model which revealed that placement students did approximately 3.5% better than non-placement students in their 2<sup>nd</sup> year of studies and have a slightly better improvement of 4% in their final year. They found that the difference between the 2<sup>nd</sup> and 3<sup>rd</sup> year was however not statistically significant. While the study confirmed that undertaking a placement year has a slight impact on the degree performance, the authors stated that there are many

limitations to their study since the data used come from only one course of study, which might not reflect same for other courses. Secondly, they assumed that a better placement essay, for example, an employer evaluation means a better placement that is there was no uniformity on the assessment process and thirdly they recognised that there might be variability of the learning opportunities offered by the different placement providers. They agreed that their findings however form the basis for further work.

In addition, [16] in their study stated that the assumption of WBL practice leading to better performance from previous studies appeared to be based predominantly on anecdotal evidence as opposed to any systematic data analysis. They conducted their study based on two cohorts of students studying Computer Science and Information Systems where the students had options to complete their studies over three years without placement or four years with one-year placement. They concluded that 58% of those students who had been on a work placement achieved an upper second or first class degree, whereas only 37% of non-placement students achieved the same academic standards. However, the conclusion reached was seen to have limitations as the length of study for both groups were not the same, one being a three year programme, the other was of four year duration. It has been observed in general at many universities that students having four-year programme (which may be without placement component) developed more maturity than those having three year programme and thus performed better in the final year. The evidence brought forward by this study is still questionable, as better results might be coming from the fact that the four-year students were more mature rather than the fact that they have opted for one-year placement. The authors acknowledged that their findings could be used as a starting point and there is need for further research that would involve investigating different cohorts of students and in different subject areas. In fact, this is one of the objectives of what this research study attempts to investigate.

### **3. Research methodology**

To investigate whether WBL practice influences academic performance of Computer Science and Information Systems students, there was need to consider secondary data about students' performances. [17] stated that secondary data are data that are gathered by someone else (e.g., researchers, institutions, other NGOs, etc.) for some purposes other than the one currently under consideration. The class of degree remains the predominant concern for students [18]. A comparative analysis was carried out on the classification of degree level obtained by Computer Science and Information Systems graduates who have undertaken WBL during their studies against those who have graduated without doing any WBL training. Secondary data of students were compiled from students who graduated over the last four years from the cohort of 2010, 2011, 2012

and 2013. Anonymity and confidentiality of students results were ensured in the research. Data were treated in strict confidentiality and no reference had made to any individual student.

#### 4. Results and discussion

The quantitative data were analysed by considering the degree classification of the four cohorts mentioned above. Each cohort consisted of students coming from Computer Science and Information Systems graduates. For the purpose of the study, only students who were awarded the honours degree were considered excluding those exiting at Diploma or Certificate level or at Pass level for the degree. Table 1 shows the number of students who were graduated with the WBL training classified as 'WBL Students' and those graduated without taking any WBL module classified as 'Non-WBL Students'. It is to be noted that students classified as 'WBL Students' in the table had undertaken at least one WBL module during the course of their studies.

**Table 1: Number of students graduated over the four cohorts**

Cohort	Field	WBL Students	Non-WBL Students
2010	Computer Science (CS)	12	55
	Information Systems (IS)	6	43
2011	Computer Science (CS)	34	48
	Information Systems (IS)	16	28
2012	Computer Science (CS)	20	55
	Information Systems (IS)	26	35
2013	Computer Science (CS)	9	22
	Information Systems (IS)	18	29

Table 2 shows the representation of students for both Computer Science and Information Systems with their degree classification over the four cohorts. It was observed that the percentage of students who obtained 'First Class' and 'Upper Second Class' was higher for students who had completed WBL as compared to those who had not undertaken. There are more non- WBL students who was awarded 'Lower Second Class' and 'Third Class' degree as compared to those who have completed the WBL training.

**Table 2: Degree Classification over the four cohorts**

		Degree Classification			
		Third Class	Upper Second Class	Lower Second Class	First Class
Students	No WBL	15.87%	46.67%	27.30%	10.16%
	WBL	13.48%	44.68%	31.20%	10.63%

The data was analysed in further depth by considering the following hypothesis:

H<sub>0</sub>: There is no significant difference in academic performance between WBL students and non-WBL students.

H<sub>1</sub>: There is a significant difference in academic performance between WBL students and non-WBL students

The academic performance was measured by considering the degree classification obtained by students at the end of their studies. A weight was assigned to the degree classification. "100 marks" was allocated for the First Class degree and "80 marks" for the Upper Second Class and so on as shown in Table 3. Similarly, a score "1" is assigned to students who have not done WBL and score "2" is allocated to WBL students. The data was tested based on the secondary data compiled for the four cohorts which involved a total of 456 students over the four years out of which 141 students have completed at least one WBL module during their studies.

**Table 3: Degree Classification weightage**

Degree Classification	Weight
First Class	100
Upper Second Class	80
Lower Second Class	60
Third Class	40

Pass	20
Diploma	10
Certificate	5

**Table 4: Descriptive Statistics for Degree Classification**

	Mean	Variance	Skewness	Kurtosis
WBL Students	67.80	290.13	0.21	-0.52
Non-WBL Students	66.35	295.87	0.31	-0.49

Descriptive statistics was carried out and the results are as shown in Table 4. The mean of WBL students being higher provides indication that students who have done WBL have a better degree classification. Positive values of skewness were observed for both categories and the data were found to be approximately symmetric being in the range of -0.5 and +0.5. It was found that the Degree Classification does not follow a normal distribution at 5% significance level as under both tests  $p = 0.000 < 5\%$  for both WBL and Non-WBL students.

As the degree classification was not normally distributed, Mann-Whitney was used to test the above hypotheses

$$H_0: \mu_{WBL} = \mu_{NonWBL}$$

$$H_1: \mu_{WBL} > \mu_{NonWBL}$$

where  $\mu_{WBL}$  = median value of degree classification for WBL students

$\mu_{NonWBL}$  = median value of degree classification for Non-WBL students

**Table 5: Ranks of Degree Classification**

	Students	N	Mean Rank	Sum of Ranks
Degree Classification	WBL	141	236.25	33311.50
	Non-WBL	315	225.03	70884.50
	Total	450		

**Table 6: Test Statistics**

	Degree Classification
Mann-Whitney U	21114.500
Wilcoxon W	70884.500
Z	-.899
Asymp. Sig. (2-tailed)	.036

$Z = -0.899$  and  $p\text{-value} = 0.036 < 5\%$ , indicate that  $H_1$  should be accepted. Therefore, the test confirmed that there was a significant difference in academic performance of WBL students compared to those having not done any WBL practice during their studies. Higher mean rank for WBL students from Table 5 further confirmed that WBL students obtained better degree classification. The result demonstrates that students completing WBL do achieve higher degree classification as compared to Non-WBL students.

Investigation was also been carried out as to whether among students who completed the WBL placement, there is any difference in academic performance of Computer Science to that Information Systems students. The following hypothesis was tested:

$H_0$ : There is no significant difference in academic performance between Computer Science and Information Systems WBL students

$H_1$ : There is a significant difference in academic performance between Computer Science and Information Systems WBL students

**Table 7: Descriptive Statistics for Degree Classification of WBL students**

	Mean	Variance	Skewness	Kurtosis
Computer Science	72.53	289.44	-0.13	-0.53
Information Systems	62.42	240.18	0.60	0.41

Descriptive statistics was carried out and the mean of Computer Science students was found to be higher than Information Systems students. It was found that the Degree Classification does not

follow a normal distribution at 5% significance level as  $p = 0.000 < 5\%$  for both Computer Science and Information Systems WBL students.

As the degree classification was not normally distributed for both Computer Science and Information Systems students, non parametric test, Mann-Whitney was used to test the above hypotheses

$$H_0: \mu_{CS} = \mu_{IS}$$

$$H_1: \mu_{CS} > \mu_{IS}$$

where  $\mu_{CS}$  = median value of degree classification for Computer Science (WBL students)

$\mu_{IS}$  = median value of degree classification for Information Systems (WBL students)

**Table 8: Ranks of Degree Classification**

	Cours e	N	Mean Rank	Sum of Ranks
Degree Classification	CS	75	82.17	6163.00
	IS	66	58.30	3848.00
	Total	141		

**Table 9: Test Statistics**

	Degree Classification
Mann-Whitney U	1637.000
Wilcoxon W	3848.000
Z	-3.698
Asymp. Sig. (2-tailed)	.000

Mean Rank for Computer Science students were observed to be higher than Information Systems students from Table 8.  $Z = -3.698$  and  $p\text{-value} = 0.000 < 5\%$ , indicate that  $H_1$  should be accepted. Therefore, the test confirmed that there is a difference in academic performance of Computer Science students as compared to Information Systems students. Computer Science students who completed WBL training perform better than their fellows in Information Systems.

## 5. Conclusion & recommendation

The study demonstrates that WBL practice influences the academic performance of Computer Science and Information Systems students. Students doing WBL practice were seen to have better

opportunities to obtain a First Class as compared to those who did not undertake the WBL training. Exposure to real work experience enhances the students' knowledge and allows them to foster better practical skills which contribute to better performance. WBL is seen to be a good contributing factor in making students achieve higher academic standard. [19] confirmed that WBL provided an excellent platform from which students could progress to the workplace and seek further opportunities for their development. The progress made during practice is found to be beneficial for students after returning from placement. Curriculum for Computer Science and Information Systems programmes must make room for work placement. [20] stresses that the Information Technology curriculum must count for practices as well as descriptive knowledge. It must include training as well as general education. This study confirmed the study conducted by [16] in 2012 where they provided evidences that work placement really does have a positive impact on the academic achievement of computing students. However, this study has not assessed the academic capability of the students before undertaking WBL training. No investigation was made about whether the students who undertook work placement were better students prior to the WBL training. Further research needs to look into the academic capability of students prior to placement.

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## **Utilization of Arts in Social Work Practice: A Review of the Literature**

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### **Abstract**

Utilization of Arts in Social Work Practice: A Review of the Literature uses multidisciplinary findings to provide an insightful perspective into the usage of various innovative artistic ideas within the field of social work practice. It provides brief examples of evidence-based and traditional art techniques that can be utilized in micro, mezzo, and macro level social work.

### **Key Concepts**

Arts, social work practice, literature review, healing artistic ideas, evidence based art form

### **Introduction**

A growing body of literature examines the use of art in the social work profession, its place in micro and macro practice, and the methods most conducive to client engagement. “Art” is a general and vague term, referring to everything from the profession being a form of art in and of itself, to visual arts, to individual and collective roles of art (creators, spectators, participants). According to the American Art Therapy Association (2013), art therapy is practiced in various settings from private practice to public institutions and community settings.

**Social work is concerned with addressing the needs of individuals, groups, and communities. Therefore, social work professionals are exposed to numerous and varied issues, from micro to macro levels. Therefore, if we are to view the social work profession as art, Gray and Webb (2008) offer a professional definition, which highlights the relationship between art, truth, and event with a purpose of serving others. Social workers themselves are artists. Art refers to those artistic methods used in the micro and macro settings to evoke different outcomes. Thus, art (in its variety of definitions and contexts) is extremely powerful in social work as it represents the capacity to foster human expression, document human experience, and give voice to those perspectives, which are most often marginalized or ignored (Cleveland, 2005).**

**Moxley, Calligan-Feen, and Washington (2012) eloquently address the different levels by which art can positively influence and can be used to promote social work values. Exposure to the arts can facilitate the cognitive, cultural, and emotional development of social workers so that they are both comfortable with and prepared to use creativity as a problem solver when appropriate. The use of arts can lead to collaboration between social workers and professionals from other disciplines who use art as a method for addressing the social issues, which they face every day. Social work educators can integrate art into social work curriculums to facilitate the processing of student emotions, as well as the difficult issues, which they are training to help clients face (Moxley et al., 2012).**

### ***The Influence of Art in Social Work Practice***

From the beginning of social work practice, scholars have debated whether the profession uses science or art, but the combination of both is what allows social work to remain crucial in today's society. Arts have emerged as a medical remedy and soul medicine for those who need it (Mcniff, 2013). *Art as medicine: Creating a therapy of the imagination* by Shaun McNiff continues to state through artistic expression and reflection the body's chemistry does indeed change. Recognizing the clarity that art gives to individuals as an expressive act alone, or a reflective tool with a group or therapist creates an awareness of how broad the term art can be. Some say, the early antecedents of art used for therapy can be traced back to the 1940's in the UK where Adrian Hill personally saw use in art helping deal with tuberculosis, and

further valuing creativity, self-expression, and being non-judgmental (Case & Dalley, 2014). Others recognize C.G. Jung's contribution in the early 1900's showing how art was used with patients in psychiatric wards or a history of psychosis (Killick & Schaverien 2013). Art is being used within large institutions and out in the community. Understanding the wide outreach of art in many fields allows the researcher to speak to the depth of influence art currently, has on social work methods.

Generally speaking, the role of art within the helping professions such as medicine, general healthcare, special education, and occupational therapy, is similar to the role it has taken in micro social work and psychology – a means of providing therapy for those suffering from psychological trauma, as a channel for self-expression and a form of communication, a means of promoting well-being and self-esteem. Although the role of art may take similar form across disciplines in the helping professions, its versatility is apparent in how it is used to achieve aims specific to different disciplines.

### ***Art across Social Work Methods – Micro Macro Phenomenon***

Although there is little research and funding focused on the effects of art as an intervention in the clinical setting, social work professionals are integrating art methods into their work with clients. On the micro side of the social work spectrum, therapists host group art therapy sessions in and hang client artwork on the walls to engage clients in conversation, as well as combat feelings of isolation (Ball & Gross, 2014). Including art as part of the therapeutic process allows individuals to creatively explore ultimate concerns of human existence (Rubin, 2016). Humans are social beings, and using art in group sessions allow them to connect, reflect on the personal journey, become aware of other stories, or work together through the process to share and learn (Case & Dalley, 2014).

Arts education is a method, which bridges the micro and macro, as both the incorporation of art into formal education curriculums, as well as the creation of informal, community-based arts education programs can facilitate youth social engagement. Using art techniques in the macro fashion can allow communities to adapt and integrate (Rubin and Babbe, 2016). Bringing individuals together in guided or open-ended art expression projects can help individuals foster a sense of self while understanding how they belong in the larger community. For instance, Hirzy (2011) discusses a particular model, which art educators often incorporate as a guide for engaging teens and adolescents entitled the *Excellence on Stage and in Life: The Mosaic Model for Youth Development through the Arts*. The Mosaic Model focuses on three outcomes: skills, which include arts discipline and skill, academic achievement and employability; self, which includes the development of a positive self-image, high self-expectations, and ambitious goal-setting; and society, which

includes respect for diversity, community involvement, and positive social capital. There exist multiple benefits for teens who engage in high-quality arts education programs that incorporate youth development practices. For example, arts education out of school, combined with youth development practices allows teens to wield more power, make rules and take risks in trying new things, and create new combinations of people, materials, and ideas (Hirzy, 2011). Catterall, Dumais, and Hampden-Thompson (2012) demonstrate that arts engagement by teens is linked to higher test scores in science and writing, completion of calculus courses, higher GPAs, higher graduation rates, and higher aspiration to attend college and higher enrollment in competitive, four-year colleges. Additional core impacts of direct participation in art making include developing an individual voice, leveraging of life skills, and creating a sense of community and belonging in the immediate art community as well as within greater society (Hirzy, 2011).

In social work, artistic tools and methods used in the macro sector of the profession range depending on the objective. For instance, the American Planning Association (n.d.) identifies storytelling and visual arts as being effective tools for understanding and exploring community values, for increasing stakeholder involvement, and for facilitating better engagement in community and urban design projects. "A body of evidence has been developing in social work which shows that crossing boundaries between the social sciences with the arts and humanities can help to communicate service users' and carers' experiences more powerfully" (Hafford-Letchfield et al., 2012). Visual art techniques such as drawing, painting, and sculpting are used in planning workshops and meetings to illustrate difficult concepts, whereas storytelling is utilized to enhance communication and collective listening. Creating an avenue to communicate verbally with metaphors or non-verbally with drawings promotes open communication among people (Edwards, 2014). Public galleries and exhibits, performances and the inclusion of art in school curricula facilitate better public engagement and stakeholder investment (both formal and informal) in those communities. Art contests, public design workshops, and collective, public space revitalization serve as a means of connecting every day users to the spaces, which they use (American Planning Association, n.d). Walton (2012) attempts to theorize an art-based method in social work education; she suggests incorporating visual arts in social work curricula as a means of enhancing comprehension of social work concepts. In her evaluation of the available literature on the use of visual and sensory methods in social work, Walton (2012) discovers that in the profession's attempt to express and develop an understanding of itself, the methods primarily relied upon are talk and text. Moxley et al. (2012) discuss the incorporation of studios as a method of teaching creativity through practical application. The studio environment is one conducive to the conceptualization and

planning of creative solutions and responses, as well as interdisciplinary collaboration and innovation (Moxley et al., 2012; Schon, 1986; Johnson, 2010).

Charpentier and Neel (n.d.) have compiled an extensive and ongoing workbook, which provides a variety of exercises and methods for social practice. Exercises range from creating a communal cookbook to art exercises, which aid in spurring conversations around racial inequality and privilege. This modality of community art allows social workers to connect with those from different backgrounds as well as different levels of ability (Waller, 2014).

The wider social work system depends on the human connection stemming from spirituality and arts (Payne, 2014). Connecting with individuals or a system of individuals, social workers are using visual methods in spheres ranging from social work education to facilitate healing in direct practice, to promoting community engagement on the macro side. However, there lacks a cohesive body of literature, which provides evidence as to which visual arts methods are most appropriate for the diverse range of social work realms (from micro to macro). Walton (2012) in her attempt to identify explanations for the effectiveness of the visual arts method in social work education, simultaneously identifies the gaps currently in existence, as well as outlines next steps for the social work field in incorporating visual arts as an evidence-based method: 1) provide evidence as to the apparent effectiveness of the visual-artistic method in social work, and 2) define a theoretical base, which will aid in shaping research and development plans.

### ***Art across the life cycle***

Micro social work is particularly concerned with treating individuals holistically. Holistic care, in this case, means taking into account all of the factors, which contribute to an individual's development – development across all life stages, environmental factors, and the micro, mezzo, and macro circumstances influencing their daily functioning. The National Endowment for the Arts (2011) reports that the arts are ideally suited to promote an integrated approach, which reaches individuals across different stages of the life cycle, across generations, and in various learning environments. Research on the influence of art reveals the following outcomes: strong connections between arts learning and education and improved cognitive development; contributions to school-readiness for children; positive academic and social outcomes for at-risk teenagers who receive arts education; added ability to contribute and problem solve for young adults who engage in

art activities; and improvements in cognitive function and quality of life for older adults who participate in arts and creative activities compared with those who do not participate.

More specifically, compared to a regular Head Start control group, children three to five years old from a low socioeconomic background who received music training showed gains in nonverbal IQ, numeracy, and spatial cognition; students from low socioeconomic backgrounds who attended an arts enrichment preschool demonstrated improved skills in school readiness (Neville, Andersson, Bagdade, Bell, Currin, Fanning, Klein, Lauinger, Pakulak, Paulsen, Sabourin, Stevens, Sundborg, Yamada, 2008; Brown, Bendett, & Armistead, 2010).

Adolescents with low socioeconomic status who were engaged in the arts (in some capacity) are more likely than their peers to attend college, gain employment, volunteer, and participate in civic activities such as voting; attendance, student behavior, and student academic achievement improved for students who were enrolled in a school, which incorporated an arts integration initiative (Catterall, 2009; Pittsburgh Public Schools ca. 2008).

Young adults are at a vital point in life where every decision seems like it defines their future. Art helps young adults respond to diverse problems, opportunities, and changes they experience on a daily basis (Landgarten and Lubbers, 2013). Engaging in art activities can help increase awareness to surrounding social justice issues, while also helping in a one on one therapy sessions. It has also been shown that those involved with the evolving world of art are more likely to contribute new ideas, techniques or theories (Ericcson, 2014).

Older adults who were engaged in a chorale program reported higher physical health, fewer doctor visits, less medicine use, fewer health programs, and fewer instances of falling. Older adults who were engaged in a theatrical intervention for at least four weeks improved in immediate work recall, problem-solving, verbal fluency, and delayed recall in comparison to two controls. Older adults with different dementia illnesses who were engaged in storytelling interventions were more alert and more engaged than those in a control group (Cohen, 2006; Noice & Noice, 2009; Fritsch, 2009).

### ***Healing aspects of Art***



A growing body of literature supports the use of art as an intervention to facilitate healing (Ball, Gross, 2014; Lyles Levy, 2014; Heenan, 2006). Heenan (2006) concluded the positive outcomes of integrating art interventions in a clinical space as spurring improvements in self-confidence and self-esteem for clients. Ball and Gross (2014) discuss the contributions art engagement can have in decreasing stress and increasing feelings of relaxation and reducing anxiety. Art is seen as a therapeutic factor reducing depression by promoting personal change having those individuals create and then verbalize (Blomdahl et al., 2013). At the Seventh Annual Women's Symposium at Fordham University, a panel of social workers speaking at the Graduate School for Social Services shared findings, which focus on the role of art in facilitating expression for clients. "Whether it is visual arts, writing therapy, poetry, drama therapy or movement, there is less resilience on verbal language...If you are really traumatized, language is not how you express yourself very well anyway – you are in shock...So [arts therapy] is a strength-based model...The focus is on resiliency versus pathology" (Bennett-Pagan, 2015).

The existing research connects art and positive outcomes for clients exhibiting and struggling with a range of issues, and which spans the micro to macro spheres of social work. Research and funding in this area are limited. The profession is calling for increased funding and research on the effect of art as an intervention on the mental health status of clients.

### ***Community-Based Art***

According to the varied and relatively recent body of literature, art appears to hold a particular role in the development, strengthening, and engagement of communities. "When local communities face conditions of physical and economic hardship, human creativity is the most valuable, dependable, and limitless resource on which they can consistently rely for positive renewal" (Pearson, 2002; p. 5). Formally, the United States is home to more than 21,750 non-profit arts, culture, and humanities organizations, holding approximately \$37 billion in assets and spending \$13.3 billion annually (Seguaro Seminar on Civic Engagement in America, 2000). Additionally, there exist tens of thousands of groups referred collectively as the "unincorporated arts," which are comprised of a range of informal arts groups ranging from church choirs to poetry slams and hip-hop groups.

Art holds a powerful role in reviving poor, minority, and disadvantaged neighborhoods by providing means of promoting interaction, increasing and broadening civic participation, engaging youth, and promoting the power and preservation (Moxley et al., 2012; Borup, 2007) Sinding et al., (2012) Pearson (2002) asserts that in order to succeed in providing positive renewal to disadvantaged communities using art, requires the work

of committed, innovative, and locally engaged professional who are able to transform local creativity into a means of real, positive action and change.

Art, for the purposes of this section, refers to cultural projects as artistic expression and civic institutions (i.e., museums, public galleries, community art organizations, performance art institutions, and arts councils and public arts organizations) based in artistic expression and work (Borup, 2007). The foundation of research concerning the effect of art on community development and engagement is founded on the research conducted by Sampson, Raudenbush, and Earls (1997), in their fifteen-year study of neighborhoods across Chicago discovered that it was not wealth, access to resources such as healthcare, or crime, which defined the levels of health of communities. Rather, Sampson et al. (1997) purported that it was “collective efficacy,” or the capacity of people to act together on matters of common interests, which defined the levels of health and well-being of neighborhoods. The National Endowment for the Arts has issued multiple reports, which strive to measure and record the influence of art on the economic health and civic engagement of communities. The Saguaro Seminar on Civic Engagement in America (2000) promotes civically desirable values and characteristics such as trust, openness, honesty, cooperation, tolerance, and respect.

However, Guetzkow (2002) identifies the difficulties in measuring the impact of the arts on communities. For instance, the definition of “arts” cannot be limited to that definition, which is provided above. Guetzkow (2002) questions the definition of “the arts,” “impact,” and “communities”:

When speaking of “the arts,” do we refer to individual participation (an audience member or direct involvement?), to the presence of arts organizations (non-profit *and* for-profit?) or to art/cultural districts, festivals or community arts?

When speaking of “impact,” do we refer to economic, cultural or social impact; do we refer to exclusivity to direct community-level effects or do we also include individual-and organizational-level ones? By “communities,” do we mean regions, cities, neighborhoods, schools or ethnic groups?

Guetzkow (2002) highlights the fact that there is no authoritative answer to the above questions; there exists no specific consensus amongst the literature on fundamental definitions, which can prove difficult in forming one mass body of literature on the effect of art on macro social work issues such as community development, ascertaining of social capital, and promoting civic engagement.

### ***Promote interaction in public space***

Public art spaces, from museums to art organizations, are civic spaces and provide an alternative source of education to participants (Saguaro Seminar on Civic Engagement in America, 2000; Moxley et al., 2012)}. Borrup (2007) first discusses the importance of public, communal space for social interaction, as these spaces allow for almost daily exposure to a variety of individuals and neighbors. Borrup (2007) purports that crowded, pedestrian-friendly, active spaces tend to be safe, economically productive, and conducive to healthy civic communities. The arts and art spaces can act as valuable resources in fostering social capital by strengthening friendships, helping communities to understand and celebrate their cultures and in providing a safe place to discuss and solve social problems. While the design of the public space is important for setting the tone of how it will be used, it is, in fact, the management of the space (i.e. how space is maintained and activities programmed), which accounts for 80 percent of the success of the space. Based on this concept, public art administrators and cultural planners can work with muralists, architects, landscape architects, and other individuals across disciplines such as engineering to create spaces, which promote public interaction and promote the safety and economic productivity characteristic of healthy civic communities (Borrup, 2007).

### ***Increase in and broadening of civic participation***

A collective effect of art is the promotion of celebration. Art provides a means, outlet, and visual representation of community culture, heritage, and identity. Broadly, culture is a driver of development and art is one manifestation of culture (Saguaro Seminar on Civic Engagement in America, 2000; Borrup, 2007; UNESCO, 2012). The American Planning Association (n.d.) discusses the use of traditional tools such as public opinion surveys, town halls, and public hearings as a means of eliciting social engagement. However, the American Planning Association (n.d.) discusses the limitations of said traditional civic engagement tools as falling short of eliciting maximum civic participation. Instead, the American Planning Association (n.d.) identifies more creative civic engagement methods such as the use of visual arts as a means of recruiting more collective participation in the civic sector. The National Endowment for the Arts (2009) claims a direct correlation between the arts and civic engagement, leading to the following conclusions

First, American adults who visit art museums and galleries, or who attend live art performances are more likely than non-attendees to vote, volunteer, or participate in community events. For instance, according to

a 2007 study, individuals the rate of individuals who volunteered at least once over a 12-month period was 35 percentage points higher for those who attended performing arts performances (57 percent) than those individuals who did not. Additionally, the volunteer rate of individuals who visited museums was more than double that of those who did not visit museums at 58 percent.

Second, those who participate in the arts sector have relatively high rates of volunteerism, which continue to prevail, despite multiple demographic factors including education, gender, age, and parental status. Third, arts participants show a greater likelihood of community involvement in other ways such as sports involvement, collaborative art-making, and taking children to out-of-school performances (National Endowment for the Arts, 2009). In sum, the literature shows a direct correlation between rates of volunteerism and other forms of civic engagement (i.e., voting), and participation in the arts.

The Seguario Seminar on Civic Engagement in America (2000) asserts that art, not only attracts civic engagement and investment but is also instrumental in broadening this through the acquisition of social capital, “Whether we are spectators, performers, or producers, the arts provide a uniquely enjoyable way to build our stock of informal social capital...Beyond the individual effects, the arts allow for public celebration and exploration of the meaning of community” (p. 1). In other words, participation in the arts, regardless of how one participates (i.e., as artist, consumer, visitor, spectator), facilitates the development of informal and collective social capital as the celebration of public art ignites a sense of civic pride - the collective can be proud of what it has collectively produced (Seguario Seminar on Civic Engagement in America, 2000). Additionally, art allows for the exploration and examination of community identity and meaning, and a means of providing a creative outlet for those communities, which are often marginalized. Art provides a safe way of bridging gaps between diverse members of the same community – those with different histories, ethnicities, and races – or members of diverse communities (Seguario Seminar on Civic Engagement in America, 2000).

Finally, art can serve as encouragement to engage in a civil dialogue concerning those issues most difficult to discuss. For example, the Vietnam Memorial, located on the mall in Washington, DC and created by Maya Lin captured and helped spur a national conversation about the complex emotions, thoughts, and memories of the controversial Vietnam War (Seguario Seminar on Civic Engagement in America, 2000).

***Youth engagement***

Borrupt (2007) stresses the importance of youth engagement in community development. Youth engagement in the arts is listed as a high priority amongst many art organizations; 100 percent of members belonging to the National Guild for Community Arts Education ranked training and information on effective music and arts programs for adolescents as one of their top priorities (Hirzy, 2011). Beyond improving art skills, high-quality arts education also improves life skills, self-image, and social commitment (for more detailed information, please see “Methods: Micro and macro”) (Hirzy, 2011).

***Promote power and preservation of place***

As mentioned previously, art is a powerful tool in increasing stakeholder involvement, as well as investment in communities. Borrupt (2007) asserts that community involvement in the design, creation, and upkeep of spaces is instrumental in developing an interest in their utilization and maintenance, as it promotes common ownership. Denzin (2013) reminds us that social work as a profession is concerned with educating people on the issues facing their communities and that the arts aid in facilitating this education, “That the arts can offer vehicles for gaining insight into social issues, and how people experience them, make both the arts and humanities especially important to social work given the profession’s commitment to taking action through partnership with people who experience first-hand the causes and consequences of social issues” (Moxley et al., 2012; p. 704). Gross (2014) discusses the instance when St. Christopher’s Hospital for Children in Philadelphia moved locations and struggled with how to make the new environment appealing to children and engaging for families. St. Christopher’s enlisted the help of a local non-profit organization, which develops community-made public art projects designed to spur social change. Pediatric patients worked with local community children to create different art pieces for the hospital and in doing so, were able to take ownership of the new space and St. Christopher’s re-engaged with the community like this (Gross, 2014).

***Art related Health and Wellness***

Similar to the way in which Gray and Webb (2008) describe social work as an art in and of itself, so too, is the medical field (Battista, Hodge, & Vineis, 1995). Battista et al. (1995) discuss medical practice as being comprised of both science and art; although the medical profession is constantly expanding on the scientific knowledge and evidence, at its core, healthcare is grounded in the interpersonal relationship between patient and caregiver. Battista et al. (1995) make the case that the art of healthcare is largely found within the interpersonal relationship and interactions between patient and doctor:

Debate over whether the clinical practice is “*artful science*” or “*scientific art*” springs in part from the shared realization that, while scientific instruments are used in the practice of medicine, these instruments do not fully define the complexity of medical practice. The integration of scientific data with the values, beliefs, and preferences of patients is at the heart of the practice of medicine, and practice must be both science and art if it is to be effective and meaningful for both patient and practitioner (p. 877).

In sum, medicine is viewed as the intersection of art and science largely due to the interpersonal and clinical nature of patient-practitioner relationships.

However, the creative and visual arts also have a place in medical education, practice, and knowledge acquisition. Glatter (2013) reports that a trend among medical school’s admissions committees is to look for a creative and visual arts background in applicants as skills in these areas may enhance the ability of students to excel, not just in medical school, but also as physicians in professional settings. “It seems that students with more ‘right brain’ qualities – related to imagery, visual and drawing skills – have begun to emerge as more successful in today’s digital, image-based world of medicine” (p. 1). Dr. Mangione, Associate Professor of Medicine at Thomas Jefferson University, points to the observation that many artists, such as Leonardo Da Vinci, are the ones who originally created diagrams of human anatomy, medical findings, and the human body. The Alpert Medical School at Brown University hosts a creative medicine series, which focuses on connecting the visual and creative arts with medical and clinical practices (Brown, n.d.).

Finally, much like in a social work clinical setting, art is used in the medical field with patients and their caregivers as a way of facilitating creative expression, working through the psychological trauma that accompanies physical injury, as a means of promoting healing, well-being, and self-esteem. Camic (2008) calls to attention the valuable place that art holds in the healthcare field:

The arts and health field takes a broad-based perspective in examining the uses of the arts in health care. It includes the work of arts therapists in clinical practice but also involves developing governmental policy, organizing community health interventions, enhancing health promotion strategies, improving the aesthetic environment of health care settings and undertaking research that examines a range of biopsychosocial factors that are impacted by arts participation (p. 288).

Camic (2008) goes on to list a range of projects in which art has been integrated into the healthcare field: artists who have participated in the design of facilities; arts programming in hospitals, music as a means of improving social cohesion, self-esteem, and cognitive functioning in older adult populations; investigating the relationship between healthcare facility aesthetics and health outcomes in patients; decreasing social isolation; in issues related to women's health, HIV/AIDS issues and hospitalized youth, and many others (Baron, 1995; Breslow, 1997; Eades, 1997; Graham-Pole & Rockwood Lane, 1997; Hays & Minichiello, 2005; Kirklin & Richardson, 2001; Isaacs, 1994; Lawson & Phiri, 2005; Mitchell, DeLange, Moletsane, Stuart, & Buthelezi, 2005; Radley & Taylor, 2003; Staricoff, 2004; Starticoff & Duncan, 2003; Staricoff, Duncan, Wright, Loppert, & Scott, 2001; Staricoff & Loppert, 2003; Wang, Morrel-Samules, Hutchison, Bell, & Pestronk, 2004; Wang, 1999.) Puig, Min Lee, Goodwin, and Sherrard (2006) integrated creative arts therapies with patients newly diagnosed with Stage I and Stage II breast cancer. The aim of the study was to use creative arts therapies to enhance emotional expression, spirituality, and psychological well-being and they found that while creative arts interventions was not effective in enhancing the emotional approach coping style of emotional expression of their levels of spirituality, creative arts therapies did enhance psychological well-being for patients through decreasing negative emotional states and augmenting positive ones (Puig et al., 2006). Johnson (1987) discussed the importance of creative arts therapies in the diagnosis and treatment of psychological trauma, as often patients have difficulty expressing themselves verbally following a traumatic incident and the creative arts provide an alternative means of self-expression. Walsh, Culpepper Martin, and Schmidt (2004) tested the efficacy of creative arts therapy interventions on caregivers whose family members were diagnosed with cancer. Walsh et al. (2004) discovered that creative art interventions did, in fact, have a positive short-term effect in reducing caregiver anxiety and stress, and increasing positive emotions.

### ***Special education***

In the field of special education, the arts provide an alternative means of teaching and learning, as well as an alternative means of facilitating growth and development (Lyons & Tropea, 1987). Andrus (2012) describes the role of art in special education as being instrumental in prevention, as it promotes self-esteem and social collaboration, decreasing feelings of isolation in students at high-risk for dropout in high schools; developing identities, art helps children in their development and search for an identity that includes a sense of competence and empowerment; and as a vital source of knowledge. Often students with special needs are put in classrooms with teachers that must connect in different ways leading teachers to use different types of activities. Evidence supports, "music promotes motivational, social and emotional development" (Bunt &

Stige, 2014). Students that can express themselves, are given the opportunity to be motivated, and have social connections, are going to be those whom grow and thrive in the school environment.

Andrus (2012) outlines strategies for teaching students with special needs (particularly those from urban areas) and includes, not only knowing those whom you teach, but also helping students discover and develop a cultural identity through art experiences, incorporating an interdisciplinary approach to art in the classroom, and including more sensory experiences through art. Wexler (2012) discusses art as a means of self-representation for individuals with developmental disabilities. Seham (2012), and Adamek and Darrow (2012) include art like dance and music as a means of facilitating self-determination and transition into community life and environments.

## Conclusion

The active integration of art in the social service professions, ranging from social work to occupational therapy, has been demonstrated as useful for achieving micro and macro aims. Tools such as The Mosaic Model help us to incorporate art and its abstract and many times subjective derivatives into more concrete configurations such as those involved in social work research and practice. A younger generation would likely benefit from catharses involving more bold forms of expression such as poetry, singing, and hip-hop. Research done by organizations such as The National Endowment of the Arts assists in proving evidence of community growth due to the usage of the arts. However, the body of research suggests that there is a shortage of theory in how and when to best integrate art interventions, and which specific interventions to use. To simply suggest that clients and patients of social workers be given a platform specifically for artist expression is just as broad as it is obvious. It can also be implied that the improper usage of these supposed techniques, in their occasionally biased and obscure nature, could potentially miscarry and cause added frustrations and feeling of incompetence for clients and patients. We must move towards a more theoretical understanding of art's place in direct, interpersonal interactions across disciplines, as well as in community building. It is essential that universities and organizations increase efforts to research possible artistic techniques as a means to provide safe, ethical, effective, and cost-efficient methods that integrate the natural necessity that is artistic expression into the improvement of lives.

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## **The status and Socioeconomic value of Cherry laurel (*Prunus laurocerasus* L.): Advancement for the future**

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### **Abstract:**

Cherry laurel (*Prunus laurocerasus* L.) is an evergreen shrub or small tree that can grow up to 6 m high; its fruit is native to the regions bordering the Black Sea in Southwestern Asia and Southeastern Europe. It is widely spread in the northern part of Turkey and very common in the Marmara region. There are many cultivars with differing characteristics in Turkey and these, as sources of germplasm, provide rich parental material for crossing. The major utilization of the crop is as fresh fruits and it is known as “taflan” or “karayemis” in Turkey. The fruit is traditionally known for its rich medicinal properties against diabetes and kidney stones. It is an integral part of the life of the people of the Black sea region where it is known as “laz kirazi”. Cherry laurel tree is generally grown as a border tree, such as around the house, gardens, or as a roadside tree. However, a few ‘monitored’ fruit-gardens of cherry laurel have been recently planted at the fruit research center. The fruits are evaluated locally for direct consumption in the local bazaars even though its other uses include as dried fruit and jam and brine preparation. Despite the fact that the cherry laurel plant is propagated vegetatively by suckers, the species has retained considerable genetic diversity in the production region. Fruit characteristics have been reported in many studies, including pomological, chemical, and nutritional values, and these studies have helped the selection of superior types from various natural populations. Importantly, such observations continue in the ‘monitored’ orchards. The tree is highly resistant



to drought, arduous soil conditions, as well as biotic and abiotic stress conditions. As the impact of climate change is one of the most important issues of the last century, such minor fruits are predicted to become more popular in the future, mainly due to their resistance to strenuous conditions. In this paper, we discuss available studies on cherry laurel, including breeding study evaluations, social and economic value predictions, health properties, and other functional uses such as ornamentation. We propose that, in future, it can be grown in small-scale conventional farms.

**Keywords:** Cherry laurel, fruit, socio-economic evaluation, breeding

## 1. Introduction

Cherry laurel is grown in a wide area covering the regions of the Black Sea from Southwestern Asia to Southeastern Europe. It is also grown in North America as an ornamental plant. There are many cultivars with different characteristics. Historically, the species was first described by the French researcher, P. Belan in 1546, in Northeastern Turkey. It is an evergreen shrub or small tree that can grow up to 6 m in height; the leaves are dark green and 5–15 cm in length and 4–10 cm in breadth (Kolayli et al. 2003). The seeds of cherry laurel are easily spread by birds, which has led to concerns regarding increasing its potential. The fruit is a small cherry that turns red to black when ripe. Most types ripen between the second half of July and August, but some types mature at the end of August to early September (Sulusoglu 2011) (Figure 1).

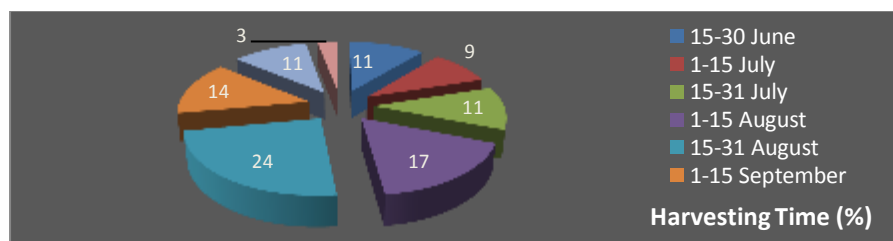


Figure 1. Harvesting time of cherry laurel fruit

Cherry laurel trees have very attractive flowers and are, therefore, a good ornamental plant. Flower buds appear in February and start to open between March and the end of April; this can take until June in some late blooming types (Figure 2). The tree and fruit are native to Turkey, among

other countries, and they are an important source of nutritious natural food and income for the rural population. The fruits of cherry laurel are not eaten as food before ripening because they are astringent and some are, possibly, poisonous. Some wild forms with very little fruit flesh, are very astringent and bitter, are not edible even after ripening, and become red-dark purple-black colored (Figure 3).



Figure 2. Leaves, buds and flowers of cherry laurel

## 2. Ecological Requirements:

The plant grows naturally in light, medium, or heavy clay soils. It has better pest resistance than most other species in the genus *Prunus* (Frohne and Pfander, 1984). It is suitable to the clay-loam soil texture found in the Black Sea Region and the temperate climate in which winters are not very cold and summers are warm-hot with rare spring frosts. The cherry laurel tree can grow in different kinds of soil, from acidic to dry climate soil without any specific preference. It is also pH tolerant, grows well in the sun or in deep shade, is salt-spray tolerant, and can withstand heavy pruning (Posta 2009).



Figure 3. Cherry laurel fruits (unmature fruits, mature fruits, Kiraz type and black type)

### 3. Cherry laurel cultivars and characteristics

Known cultivars of Cherry laurel are listed in Table 1 in (Anonymous 2017a,b,c; Huxley 1992). In Turkey, some common names for these cultivars are Su, Vavul, Yabani, Ağustos-İstavrit, Orak, Ayran, and Kiraz. Vavul is more fleshy but has less fruits per branch; Kiraz matures in mid-June, but is tasty and slightly sour; Orak matures in mid-July and is very delicious; Su matures in mid-June and has a bitter taste (İslam 2002, Bostan 2001, Sulusoglu 2016) (Figure 3).

### 4. Status and Socioeconomic value of Cherry laurel

Fruits are astringent before maturity but become sweet and reasonably pleasant when fully ripe. Cultivated plants have bigger, sweeter tasting fruit, and are marketed locally for table consumption. While it is mostly consumed as fresh fruit in local markets, the cherry laurel fruits are also used in making jam, pickle, and cake. It is also consumed as dried fruit and has gained popularity in the recent years (Sulusoglu 2011). Although it has other uses, the preparation of brine with onion in oil is very common and it is used for cooking food during winter.

The fruits and seeds of this tree have been used as traditional medicines against diabetes, stomachaches, cancer, skin problems, cholesterol, hemorrhoids, and for decreasing blood pressure. Fresh leaves are used in herbal medicine for their antispasmodic, narcotic, and sedative properties. It is also a good diet fruit that gives satiety but is associated with the formation of kidney stones when eaten with the stone. However, powder from the fruit stone is considered beneficial for bronchitis. The fruits also positively affect the blood acid-base balance and fresh leaves are used to prepare 'laurocerasus water', in pharmacies, for antispasmodic and breathing diseases (Sulusoglu 2016). Cherry laurel fruits are considered significant sources of phenolic compounds and anthocyanins (Grieve, 1984; Kolaylı et al., 2003). As it is generally cultivated like a border tree, they are rarely present in closed orchards; both of these have resulted in insufficient culture treatments and low

productivity. As the Cherry laurel is a decorative plant when it is in full bloom, it is used in parks and gardens as an ornamental plant, and its foliage is also used as cut greenery in floristry (Sulusoglu 2016).

Table 1. Name of the cherry laurel types-cultivars and characteristics

Name of cultivar and types	Characteristics	References and Place
Kiraz	Kiraz' cherry laurel is a table cultivar and one of the important varieties grown in Trabzon province of Turkey.	İslam, 2002, Turkey
Su	Very juicy and has an attractive color of skin and flesh.	Bostan 2001, Turkey
Mount Vernon	Slow-growing, compact dwarf to 90 cm, wide spreading, dense, leaves similar to species	USA, Anonymous 2017(a)
Otto Luyken	Popular form, compact, spreading to 1.8–3 m wide and 1.5 m tall, erect stems, narrow, glossy dark green leaves, abundant flowers	Huxley, 1992
Schipkaensis	Several forms have this name. Moderate growing to 1.2–1.8 m tall and 1.8–2.4 m wide.	USA (Anonymous 2017(b))
Nana	A dwarf cherry laurel, slow growing to 1.2–1.6 m tall and wide, spreading, glossy dark green leaves similar to species.	USA, Anonymous 2017(c)
Marbled Dragon	Slow growing, leaves marbled gray or white, variable and unstable	USA, Anonymous 2017(b)
Magnolia	A very large-growing form, this selection bears large foliage that resembles <i>Magnolia grandiflora</i> and is lustrous dark green. The plant may be grown to a tree.	Huxley, 1992

Cherry laurel grows naturally, does not require pesticide application, and is resistant to high humidity or arid conditions (Sulusoglu 2011). The uses of cherry laurel fruits are a result of traditional habits rather than economics, mainly because of varietal heterogeneity and the lack of selection and identification of genotypes. Traditionally, in the Black sea region, almost every house has one tree in its garden, and because of this popularity, it is said that, if there is a cherry laurel tree somewhere, the owner is probably from the Black sea region.

## 5. Breeding Studies

The Cherry laurel fruit is steadily gaining commercial popularity in the United States, Europe, and Turkey (Foley and Raulston 1994; Sulusoglu 2011), even though it is traditionally cultivated in Turkey. Such minor fruits are of economic importance for the local people, forest

villagers, and for the future human generations, as they are resistant to a range of biotic and abiotic stressors, have limited needs, require minimal care, and yet produce nutritionally healthy fruits.

Studies on breeding of this species have focused on the selection of superior cultivars with maximum resistance to disease, environmental adaptability, and molecular mapping of these cultivars. Unfortunately, breeding programs to obtain cultivars with high fruit quality have rarely been attempted (Islam and Odabas, 1996; Islam and Vardal, 2009). Due to its increasing market value, the demand for the fruit by producers and the processing industry has increased and presents an impetus to develop commercial cultivars.

Studies have been conducted to select superior cultivars from different regions in Turkey. Trees with different ages at different locations and under various growing conditions were identified and some of their pomological and chemical traits were determined. The first such study in literature was by Özbek (1952) in the Giresun forest area. Özbek (1952) traveled in the Black Sea Region and investigated tree and fruit characteristics of this species, and subsequent investigators have used these characteristics in the Trabzon, Rize, Ordu, Samsun, Sakarya, and Kocaeli cities of Turkey (İslam 1996; Islam and Odabas 1996; Islam and Vardal 2009; Beyhan 2010; Sulusoglu 2011; Macit and Demirsoy 2012).

Pomological studies indicate that genotypes selected as ‘promising’ could indeed improve the cultivation of this fruit. Based on the results of phenological and pomological analyses, some genotypes were identified as potential sources of raw material for breeding programs. However, adaptation studies, which form the second phase of the selection procedure, need to be organized in the potential areas of cultivation.

Genetic characterization of the different types and their molecular studies constitute other important steps in the breeding process. The taxonomic classification within the genus *Prunus*, which is mainly based on fruit morphology, remains controversial. The subgenera *Padus* and *Laurocerasus*, in which the Cherry laurel is placed, is more isolated within the genus *Prucultivars*, with same

characteristics, but assigned different names, resulting in too many types and genotypes in the selection studies (Aradhya et al. 2004). A few genetic-molecular analyses among cherry laurel genotypes have been reported (Hajyzadeh et al 2013; Sandalli et al, 2005; Lee and Wen, 2001; Bortiri et al, 2001).

Biological characteristics such as pollen germination and viability, ideal fertilizer selection, fruit set, and the effects of pollinators on fruit quality are very important, and such characteristics have been investigated for cherry laurel (Sulusoglu and Cavusoglu 2014a, Sulusoglu and Cavusoglu 2014b). In these studies, various cherry laurel genotypes were investigated that showed satisfactory in vitro pollen viability and germination. The initial number of fruit set was very high and did not differ based on the pollen source. On the other hand, there were significant differences among the genotypes and pollinators during final fruit set. These results provide preliminary information on the biological characteristics of cherry laurel for use in breeding programs. A continuation of such studies should focus on utilization of new pollinators, fruit set in different combinations of cross-pollination, and the dynamics of pollen tube growth in the pistil.

## **6. Propagation Studies:**

The propagation of the selected genotypes using cuttings (Riberio et al. 2010; Yazici et al. 2009; Posta 2009; Sulusoglu and Cavusoglu 2010) or in vitro studies have been successfully conducted in this species. Economical mass propagation of cherry laurel is an important step for the commercial production of saplings. The semi-hardwood cuttings of sixteen cherry laurel types, selected considering their pomological properties (Sulusoglu, 2011), were reported to root successfully using IBA(Indole-3 butyric acid) , and thus, superior rooting genotypes were identified for use in commercial orchards (Sulusoglu and Cavusoglu 2010).

In vitro proliferation could provide an alternative and rapid means of producing cherry laurel saplings (Ponchia, 1991; Kalinina and Brown 2007; Sulusoglu and Cavusoglu 2013) and one study used embryo culture of cherry laurel for breeding. In this study, large differences among the types

Cherry laurel is a part of the daily life of people in the Black Sea region and is a traditional fruit with a promising future. Appropriate breeding steps can identify and improve genotypes to meet production quality standards. Molecular studies could support the selection of superior genotypes before cultivation and conservation of plant material. Selected genotypes will serve as the source of new cultivars for the Cherry laurel, and certificated saplings of the new cultivars can be used to populate new plantation areas. Finally, creating awareness through social networks can increase recognition of cherry laurel in other countries as well.

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## **The Face of Technological Entrepreneurship**

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### **Abstract**

Based on an exploratory approach, this research project aims to understand technological entrepreneurship. Eleven semi-structured interviews were conducted in 2017 with entrepreneurs who create technology, from the province of Québec, in Canada. The analysis of their experiences made it possible to identify the success factors and barriers of technological entrepreneurship. These factors were analyzed according to the stages of innovation: conception, implementation, and marketing. As a result, this research provides a portrait of technological entrepreneurship by not only providing recommendations for budding technological entrepreneurs, but also by identifying some leads for future research.

### **Keywords**

Entrepreneur; technological entrepreneurship.

### **Introduction**

Entrepreneurship is a research field interested in the discovery and exploitation of profitable opportunities (Shane and Venkataraman, 2003). These opportunities can only be exploited by the know-how and creativity of individuals who are described as entrepreneurs. In recent years, a new trend has emerged, namely technological entrepreneurship. More and more, companies develop technological innovations to launch new products related to these innovations. These new products can revitalize a declining industry or even create a new one. Although the development and commercialization of new technologies are important for economic growth, the study of technological entrepreneurship remains unique and singular. Indeed, this type of entrepreneurship is less linear and predictable than traditional entrepreneurship. Nevertheless, it brings enormous potential to regions and job creation. Technological entrepreneurship aims to create new

technology companies (Shane and Venkataraman, 2003). It differs from classical entrepreneurship by developing new products and assets that are closely linked to advances in scientific and technological knowledge.

The objective of this research is to understand the dynamics of technological entrepreneurship and to define its outlines. To do so, an exploratory study based on semi-directed interviews was conducted with eleven technology companies in the province of Québec, in Canada. The data were analyzed according to the three phases of the simplified innovation process (Tiwari, 2007): conception, implementation, and marketing. The main findings highlight key success factors and barriers.

### **Concept of technological entrepreneurship**

Bailetti (2012) conducted a literature review on technological entrepreneurship. He identified the various definitions of this concept among the scientific articles published between January 1, 1970 and December 31, 2011. Thus, 93 articles published in 63 journals were retained during this census. First of all, Jones-Evans (1995) and Nichols and Armstrong (2003) define technological entrepreneurship as the creation of a technology-driven firm. Venkataraman and Saravathy (2001), however, remain global in addressing the challenges of this type of entrepreneurship. Other authors have identified the necessary elements for technological entrepreneurship. Garud and Karnøe (2003) discussed the processes and actors involved. Moreover, according to them, the technological firm is an agency that creates inputs necessary for the emergence of a technology. Liu et al. (2005) indicate the importance of resources and structures. Based on this review of the literature, Bailetti (2012) defines technological entrepreneurship as "an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm."

The analysis of the literature revealed several success factors of technological entrepreneurship: the understanding of the market and of the user (Ottenbacher and Harrington, 2008; Altuntas and Deleri, 2012); the technological dimension (Cooper, 1981; Astebro, 2004); the human dimension (Ottenbacher and Harrington, 2008; Karaveg et al., 2016); the financial dimension (Karaveg et al., 2016); and the managerial dimension (Ottenbacher and Harrington, 2008).

### **Innovation process**

Although there exist several processes of innovation in the literature, this study adopts Tiwari's simplified process model of innovation (2007). This process, presented in the figure below, consists of three phases to study technological entrepreneurship projects. The simplification of the innovation process, addressed by this model, makes it easier to analyze and classify results although in reality, innovation is not necessarily linear.

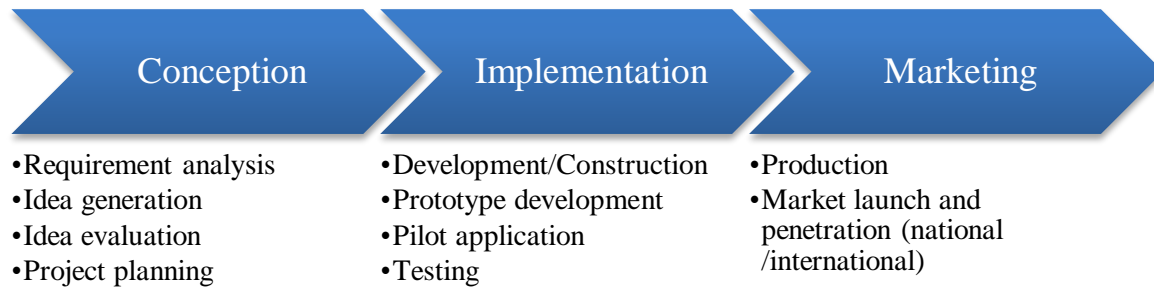


Figure 1 : Simplified innovation process, source: Tiwari, 2007.

## Research objectives

This research aims to understand technological entrepreneurship. Several studies have shown that innovation, especially technological innovation, is central to technological entrepreneurship (Shane and Venkataraman, 2003; Quinn, 1979). In addition, in the literature, many terminologies are used by researchers and practitioners to name a technological company, such as: high-tech enterprise, technological company, innovative company, knowledge-based firm, high-tech start-up, university spin-off, research-based start-up (Borges et al., 2005). We will therefore try to identify the success factors and the obstacles of technological entrepreneurship. As a result, these success factors and barriers will be analyzed according to the phases of the simplified innovation process (Tiwari, 2007): conception, implementation, and marketing. The results of this study will not only provide a portrait of technological entrepreneurship, but will also provide recommendations to future technology entrepreneurs. It is now important to discuss the adopted methodology.

## Methodology

Based on an exploratory approach (Miles and Huberman, 2005), this research aims to understand a phenomenon not well-known to researchers (Thietart, 2014). Indeed, this approach makes it possible to better understand the phenomenon of technological entrepreneurship thanks to its inductive approach (Gauthier, 2016). A sampling of convenience was conducted with the help of governmental support agencies. Indeed, the aim of this qualitative research is to build theoretically and thus ensure internal validity (Thietart, 2014). The objective is not to generalize the results on the whole population studied. Moreover, using a sample of this size (11 technological entrepreneurs), a probabilistic method would have brought too important biases (Thietart, 2014). Thus, each of the

identified entrepreneurs received an email explaining the research project. Subsequently, a call was made during the same week. Finally, eleven semi-directed interviews were conducted from January to April 2017 with technology entrepreneurs. At the end of these interviews, only one company was in the conception phase of the simplified innovation process, four companies were in the implementation phase, and finally six companies were currently commercializing their product in the marketing phase. The methodology of this research project and the interview grid were previously validated by the Research Ethics Committee of the Université du Québec à Rimouski. Each interview, with an average duration of one hour, was recorded on a digital medium and subsequently transcribed. The set of verbatim accounts was codified and was the subject of a thematic analysis (Allard-Poesi et al., 2003) with the Nvivo version 11 software. The analysis of the data was carried out by four researchers in the field.

## **Results**

The analysis of the interviews helped to understand the dynamics of technological entrepreneurship by identifying the success factors of technological entrepreneurs. Several respondents noted that the technology entrepreneur must not only have a lot of energy, but also be stubborn in order to succeed. The various success factors were analyzed according to the three phases of innovation (Tiwari, 2007): conception, implementation, and marketing. When analyzing these phases, many dimensions will be studied: the market and the user dimension; the technological, human, and financial dimensions; and the managerial dimension.

### ***Conception phase***

The conception phase includes: "requirement analysis, idea generation, idea evaluation, and project planning". The eleven companies studied have implemented or are currently implementing this conception phase.

#### **Market and user**

Understanding the market has proven to be a major success factor in the conception phase of the simplified process of innovation. By solving a real problem, the entrepreneur can look for a more targeted clientele. The technological entrepreneur must meet a real need, so he has to work on a real problem. According to Interview # 1: "You have to have something that people will need or will want to get hold of." The notion of "timing" is therefore an important factor that emerged from the interviews, that is, to really understand the evolution of the market in order to offer, at the right time, the product answering the user's need. Ottenbacher and Harrington (2008) point out the importance

of understanding the user. The authors emphasize that the understanding of customers, especially of the user, is even more important than knowing the market in a global way. Indeed, technology entrepreneurs often work to meet demand in a market segment (a niche) rather than in a mass industry. It is therefore necessary, during idea creation and product development, to collaborate closely with the user. The latter will then have to grasp the added value created by the firm (Smith and Nagle, 2002). However, Ottenbacher and Harrington (2008) argue that conducting market research is not a determinant factor in the success of a technology firm, due to SMEs' limited resources and the entrepreneur's leadership ability, thus making the market study unnecessary. Altuntas and Deleri (2012) argue, on the contrary, that it is important to take into account market assessment, the geographical location of the company according to the socio-economic situation of the city, and the assessment of product perception by the market. Moreover, the analysis of the interviews confirmed this importance. According to Interview # 1: "You have to do market research, make sure there is a demand, and that you do not work in a vacuum." In addition to understanding the market and the user, available resources, including technological resources, are success factors of technological entrepreneurship in the first phase of the innovation process.

#### Technological dimension

During the conception phase, the technological entrepreneur aims to create new knowledge which requires time, especially when a university is involved. Nevertheless, it is pertinent to work with research institutes, universities, and colleges. The presence of these players in the company's environment influences its capacity for innovation (Castonguay, 2014). Moreover, the protection of industrial secrecy is a daily challenge, which is also confirmed by the literature (Castonguay, 2014). According to Interview # 2, the technological entrepreneur must make "a marriage between the knowledge of the market and of the need, and the knowledge of the technology to meet that need." In fact, Cooper (1981) and Astebro (2004) note that one of the success factors of entrepreneurship projects is the compatibility of the technological resources. While technological resources are important in this phase, some respondents pointed out that the entrepreneur should not be "technology-minded". Rather, he must be able to make the right choice of technology and evolve with it, without necessarily taking refuge in the first technology adopted. Therefore, it is important that the company "have technically strong people, to analyze technological choices." (Interview # 2). Technical skills are therefore key success factors (Karaveg et al., 2016).

#### Human dimension

The success of this conception phase is based on "the person who has thought about the characteristics of the product and who has a very good knowledge of the market." (Interview # 2). It is important that the technological entrepreneur be constantly challenged by people "who are brighter than you" (Interview # 3), who have different perspectives. Generally speaking, respondents indicated that it is crucial for the success of the product conception phase to be well surrounded by the right people. According to Interview # 3, the success of the entrepreneur is "in the way of

surrounding yourself with people you trust and who are brighter than you". Karaveg et al. (2016) point out that human resources are a success factor in R & D projects. The entrepreneur must therefore "have the right resources to complete the project." (Interview # 1).

#### Financial dimension

Confirming the work of Cooper and Edgett (1999) and Karaveg et al. (2016), financial resources are a success factor as early as the conception phase. Several respondents stressed the need for capital and good control over expenditures. The importance of a good financial structure also emerged from the interviews. In addition, one respondent pointed out that "we did not want to go into debt." (Interview # 4). Several respondents used alternative strategies to conventional financing: love money, business angels, venture capital, and even franchise systems to provide the liquidity needed for product conception.

#### Managerial dimension

Few factors related to the managerial dimension were identified during the conception phase. Nevertheless, respondents argued that the entrepreneur must pay particular attention to ensure that the financial partners are satisfied. He must also select them well. According to Interview # 4: "Good partners attract good partners and bad ones attract the wrong ones."

The second phase of the simplified process of innovation is the implementation phase.

### ***Implementation phase***

This phase includes: "development / construction, prototype development, pilot application, and testing". Only one of the eleven companies studied had not reached this implementation stage. Four companies were currently testing and developing their prototype. Finally, six companies had already completed this phase. In this phase, the success factors related to the understanding of the market and of the user, and to the various dimensions are different from the conception phase of the simplified process of innovation.

#### Market and user

During the implementation phase, understanding the user is still important, but for a different reason. In fact, the entrepreneur no longer seeks to understand the need for use but rather, needs to develop a solution that will address his problem. Ottenbacher and Harrington (2008) argue that one of the success factors of technological projects is understanding the market: "Make sure that they have

priced the project according to the target market." Therefore, the entrepreneur needs a first customer to test his product: "It takes first customers who will try this [product]." (Interview # 5). One of the success factors of this implementation phase is "getting challenged as quickly as possible." (Interview # 6).

#### Technological dimension

There are several tests and trials to be carried out in order to overcome the technological challenges in the implementation phase. Some respondents argue that they had not anticipated the risks of implementing their technologies and that these are major obstacles: "We did not see the risk of implantation in certain technologies [...] to implant them in the time and in the cost that had been foreseen, on this we had more difficulties." (Interview # 2). In addition, respondents stressed the need to split up information when dealing with collaborators, such as suppliers or testing laboratories. According to Landry et al. (2006), one of the ways to protect the knowledge of a company is secrecy or the splitting up of information. Indeed, it is recommended to use various strategies of knowledge protection when the company has exchanges with external actors (Castonguay, 2014).

#### Human dimension

The analysis of the interviews revealed that the collaboration of human resources, particularly of employees and customers, is a success factor of the implementation phase in technological entrepreneurship projects. This confirms the work of Ottenbacher and Harrington (2008). The interviews revealed that teamwork and collaboration provide "appropriate solutions to [clients'] problems." It is important to have access to people with great expertise: "We have people who have a broader expertise than us, it's a factor of success." (Interview # 4). However, since several technology companies are SMEs, they have limited resources. These limited resources often require the same human resources to be involved in several activities in both product development and technical support. Human resources are factors that determine technological projects, including R & D projects (Karaveg et al., 2016).

#### Financial dimension

The respondents, on the one hand, argued that the costs and the need for working capital are often higher than expected: "Funding at this stage is very difficult." (Interview # 5); "There is a much greater chance that there will be a funding failure than a technology failure." (Interview # 7). On the other hand, several financial



solutions are available at this stage, notably "subsidies and government grants, there are so many." (Interview # 4). As reported by Riding, Orser et al. (2012), the literature deals extensively with the technological entrepreneur's need for financing. It emerges from the need to compensate for the delay between the time when revenues are collected and the expenditures are incurred, in addition to the need for investments to obtain or increase production capacity.

#### Managerial dimension

Management skills influence the success of technology projects (Ottenbacher and Harrington, 2008). A few management problems arose in the respondents' implementation phase. Problems related to the satisfaction of the financial partners and shareholders were raised by the respondents. Moreover, according to Interview # 7, this phase "is very risky. Shareholders can leave if anything [negative] happens." It is not necessarily the financial aspect, but rather the management of communications with these partners that is worrisome. Several respondents mentioned that it is important to manage the relations with financial partners well. They must be kept informed of the actual situation and the real problems in progress. Moreover, one of the respondents indicated that it is important to choose financial partners who have experience in entrepreneurship, in order to facilitate the management of communications with them. In addition to the communications management challenge, this implementation phase requires good time management. Indeed, the time required to carry out this step is often underestimated: "It put pressure on the whole organization." (Interview # 2).

Finally, the last phase of the simplified process of innovation is the marketing phase.

#### **Marketing phase**

This marketing phase includes: "production, market launch, and penetration (national / international)." This is the way that the new innovations will spread in the domestic / international market, through marketing and commercialization techniques. Although they may be rich in new ideas, design and development, technological entrepreneurs are generally poor in resources to market their products or technologies. Technology entrepreneurs are often researchers or engineers (Albert, 2000). They generally have a good mastery of technical knowledge, but they have certain shortcomings in the field of management and marketing. These two skills are generally the most deficient among technological entrepreneurs (Borges et al., 2005). In our exploratory study, only six of the eleven companies were currently marketing their product and penetrating the market. In this phase, the various success factors differ between the first two phases of the simplified process of innovation. Indeed, the success factors linked to the managerial dimension take on more importance than those linked to the technological dimension, since the proofs of concepts and the prototypes' tests have already been carried out.

### Market and user

First, respondents emphasized the importance of proving the product's benefits to the user in order to persuade him to purchase the product: "To market, you have to be able to prove that the savings on [the product] are reproducible." (Interview # 8). The analysis of the interviews identified two other success factors related to the marketing phase. One respondent noted that "market acceptability is never obvious." (Interview # 5). It seems difficult to gain access to the market, especially for an SME with limited resources. It is also important to "have a global presence with certain employees, to have this feedback from the market. Feel also the competition, what is happening, in order to develop the right products." (Interview # 2). This global presence is likely to improve the product. The commercialization of an innovation requires market data so it can be disseminated when it is launched. (Karaveg et al., 2016)

### Technological dimension

On the one hand, none of the respondents addressed the technological dimension in this last phase of the simplified process of innovation. On the other hand, the importance of a good distributor was emphasized. Karaveg et al. (2016) underline the importance of products being free of flaws in order to avoid high costs.

### Human dimension

Some respondents mentioned that finding a good distributor was a success factor in the marketing phase. Moreover, according to Interview # 4, there are two criteria to select the right distributor: "First criterion: someone who knows very well his target market, he must be in the target market. Second criterion: someone with sufficient technical knowledge." Citing numerous studies on the subject, Karaveg et al. (2016) consider human resources as the most important factor in technology research and development.

### Financial dimension

The limited financial resources of SMEs appear to be an obstacle to the completion of the marketing phase: "Given that we are an SME, we cannot make immense marketing efforts." (Interview # 9). As a result, financial resources represent a factor determining the success of the commercialization of technology entrepreneurship projects. Several studies conclude that inappropriate financing is the

fundamental obstacle to the establishment of technology companies (Willoughby, 2008), particularly due to the volatility of this type of firm and the difficulty in estimating its cash flows (Pereiro 2016).

### Managerial dimension

Several success factors related to the managerial dimension were identified during the interviews. First, it is important to "be realistic in sales goals." (Interview # 9). In this way, the entrepreneur can make better forecasts. He must also be "agile and flexible." (Interview # 9). It is also important to have a marketing procedure: "There are four main steps in marketing and commercialization: the first step, the goal at the moment, is to produce as many products as possible to establish our credibility and get as much feedback as possible. [...] The second step in fact is to collect feedback on our product, to be able to improve. The third step is to keep these first users as happy as possible and to take good care of them. The fourth step is to make these people your ambassadors, proud to have the first version of the technology that is in development. So it's important to retain them, to keep in touch, and to use them to exert leverage and have more sales." (Interview # 9). However, the technological entrepreneur must overcome the legal and conformity barriers in order to successfully commercialize his product: "Customs compliance is also very important, it's a whole world. It is a major barrier to commercialization." (Interview # 4). The importance of hiring skilled employees in strategic positions in the company, particularly at the managerial level, is raised, in particular by Karaveg et al. (2016).

The analysis of the success factors presented in the table below gives a portrait of technological entrepreneurship (The Face of Technological Entrepreneurship).

	Conception phase	Implementation phase	Marketing phase
Market and user	<ul style="list-style-type: none"> <li>• Solve a real problem</li> <li>• Timing</li> <li>• Market and user understanding</li> </ul>	<ul style="list-style-type: none"> <li>• Develop a solution to the problem</li> <li>• Need for first customers</li> <li>• Be challenged</li> </ul>	<ul style="list-style-type: none"> <li>• Prove the benefits of the product</li> <li>• Market access</li> <li>• Have a global presence</li> </ul>

Technological dimension	<ul style="list-style-type: none"> <li>• Time</li> <li>• Protecting industrial secrets</li> <li>• Make the good technology choice</li> <li>• Not be married to the technology</li> </ul>	<ul style="list-style-type: none"> <li>• Carry out tests and trials in order to overcome technical challenges</li> <li>• Split up information</li> <li>• Protect knowledge</li> </ul>	<ul style="list-style-type: none"> <li>• No factors identified in the interviews</li> </ul>
Human dimension	<ul style="list-style-type: none"> <li>• Surround yourself with the right people</li> <li>• Be constantly challenged by brilliant people</li> </ul>	<ul style="list-style-type: none"> <li>• Work as a team and collaborate</li> <li>• Access to experts</li> </ul>	<ul style="list-style-type: none"> <li>• Find a good distributor who knows the market and technology</li> </ul>
Financial dimension	<ul style="list-style-type: none"> <li>• Available capital</li> <li>• Manage spending</li> <li>• Good financial structure</li> <li>• Low indebtedness</li> </ul>	<ul style="list-style-type: none"> <li>• Need for working capital</li> <li>• Manage spending</li> <li>• Take advantage of government grants and subsidies</li> </ul>	<ul style="list-style-type: none"> <li>• Need for financial resources</li> </ul>
Managerial dimension	<ul style="list-style-type: none"> <li>• Choose the right financial partners</li> <li>• Satisfy the financial partners</li> </ul>	<ul style="list-style-type: none"> <li>• Satisfy financial partners</li> <li>• Manage relations with financial partners</li> </ul>	<ul style="list-style-type: none"> <li>• Be realistic in sales objectives</li> <li>• Be agile and flexible</li> <li>• Adopt a marketing process</li> <li>• Pay special attention to legal and compliance barriers</li> </ul>

Table 1: Success factors of technological entrepreneurship according to the phases of the simplified process of innovation.

According to the respondents, technological entrepreneurs expected a more technical challenge than a managerial challenge, which was only true for the conception phase. Moreover, no success factor relating to the technological dimension was identified during the last phase of the simplified process of innovation. Nevertheless, the managerial dimension is more important than the technical aspect for the last two phases, implementation and marketing. Indeed, the success factors related to management skills are more important than the technological dimension because the proofs of concepts and the prototypes' testing are already carried out at this stage.

## Conclusion

In conclusion, the analysis of these eleven interviews made it possible to identify and understand the differences between the success factors of technological entrepreneurship during the three phases of the simplified process of innovation. Although the results of this study have made it possible to understand technological entrepreneurship by portraying it, they cannot be generalized. However,

from a managerial point of view, the results of our research can serve as guidelines for future entrepreneurs from which they can draw inspiration, in order to set up the success factors at the very beginning of their technological innovation project. Future research, particularly on different alternative financing strategies in the framework of a technological entrepreneurship project, would be relevant. Indeed, the financial dimension has proved crucial to the success of technological entrepreneurship and this, at every phase of the simplified process of innovation.

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## **The Subjective Comfort Ratings of Customized Handles**

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### **Abstract**

With the advancements of 3D scan and 3D print techniques, the measurements of hand surface data could be used to customize and design users' own personal hand tools. The purpose of this study is to apply the 3D scanning and alginate method to acquire the complementary 3D surface data of hand in gripping a handle, and to print the new type of handles by 3D printer. Twelve adults were recruited to customize their own handles. Firstly, alginate material was applied to mock up the complementary 3D surface of hand in gripping a handle. The 3D scanner was then applied to acquire the 3D surface data, and print it by 3D printer. This study applied a series of questionnaires to assess the comfort of the tool handle, which fit in the palm of the user's hand. The results showed that the participants had high subjective comfort ratings for their customized handles. The future research will evaluate the difference in subjective ratings between customized and old type of handles under different physical loads.

**Keywords:** 3D scan, 3D print, complementary 3D surface data, customized handle, subjective ratings

### **Introduction**

This study mainly applied 3D scanner and 3D printer to fit the power-grasp shape design in order to allow users to have better comfort. To fit the grip shape design means that the shape of the power grasp can be tightly fitted to the hand. In this study, a 3D surface scanner was used to obtain the 3D surface data when the hand was in its power-grasp posture. The 3D printer was used to consequently giving the appearance of a custom handle.

In our daily life and work, the use of hand tools is very frequent for undertaking tasks. We have to use our own hands to maneuver or operate the equipment or tool, such as screwdriver, bicycle or motorcycle handle, mouse, smartphone, bat and electric drill. The design of the hand can be divided into two aspects: One is the protection of the hand (such as providing warm, shockproof, and chemical-resistant gloves). The

other one is the fit of the interface with the hand tool [1]. Regardless of glove or hand tool, it is important to fit the surface of the hand since it may significantly affect the comfort of the glove and the performance of the hand tool when using the hand tool. The fit will also affect its control [2]. So the design of the hand tool may be more appropriate for conducting work to allow better finger for manipulations with the tool. Hand data had been applied to the development of a glove sizing and the design of a glove pattern for better fit to the hand [3]. The contact surface of the hand and the grip affects the fatigue of the force and musculoskeletal system, which in turn affects the comfort and safety of the hand tool.

However, most of the related studies about measurement of the hand were only for the straight posture, with less consideration to the contact with the object. It is more difficult to apply the hand measurement directly to the handgrip or operation-related design. The more hand measurements we have, the more effective and efficient ways to evaluate the suitability of the hand tool design [1]. However, too much hand measurements may even confuse our application design. To the design of hand tools, the main consideration is that the design can demonstrate its maximum performance with minimal loads on muscles, tendons, joints, and skin. In most parts of this design issues focus on optimizing hand tool contact points in order to maximize grip strength, minimize contact stress with an interest to sensitive areas of the palm and wrist, and provide appropriate tactile feedback [4].

With the development of 3D scanner and 3D printing technology, new technology provides an ideal way especially for 3D scanner with high resolution (0.8~2mm), which operates very fast, and does not touch the human body [5-10]. The 3D scanner also allows us to get our body surface data in line with our real human body. The complementary palm surface data can then be easily calculated. 3D printer is then used to determine the appearance of hand tool for reaching its maximal fitness for the palm and finger, which are in contact with the hand tool. It is noted that the resulting design will not cause additional burden due to floating. Harih & Dolšak [11] used MRI and 3D editing software to obtain the hand surface data at the time of holding power grasp, and then obtained the surface data of the hollow core. In this way, the impact on the contact area, comfort and performance of the palm of the hand was discussed. It was found that the risk of physical and repetitive injury was low, and the contact area, performance and subjective comfort were all increased. However, when scanning with a hand-held 3D scanner, there are many holes of the surface of palm due to the number of shaded areas and the semi-closed state. So there is a need to fill up the holes, which may consume a lot of manpower and time. This study is expected to apply alginate method to obtain the complementary palm surface area. This method should be effective in saving manpower and time, and can get a more real surface.

Therefore, the purpose of this study can be divided into:



1. Apply the 3D scanner and Beauty 3D® software to obtain complementary surface area for the subject's power-grasp posture.
2. Apply 3D printer to print out of the new customized handle for each participant.
3. Discuss the subjective ratings of comfort of customized handles.

## **Research Methods**

### **2.1 Samples**

This study recruited twelve participants, which half were males and half females. The hand length of males is between 18.0 and 20.1 cm, with an average of 18.9 ( $\pm 0.8$ ) cm. The hand width of males is between 8.1 and 9.2 cm, with an average of 8.6 ( $\pm 0.4$ ) cm; while the hand length of females is between 15.5 and 18.0 cm, with an average of 16.8 ( $\pm 0.9$ ) cm. The hand width of females is between 7.0 and 7.6 cm, with an average of 7.3 ( $\pm 0.3$ ) cm.

### **2.2 3D data acquirement**

In this study, we applied the alginate method to mock up the complementary 3D surface of hand in power-grasp posture, and then applied a high-resolution 3D hand surface measuring instrument for detailed scanning. We then scanned the data and filled the hole for acquiring the complementary palm surface data.

Firstly, we applied the alginate materials to obtain the hollow area of the palm in the power-grasp posture of the participant (see figure 1). Related research also used alginate materials as a material for obtaining the surface of the hand [12-14].

A 3D surface scanner (Logistic Tech, Taiwan) was then applied to scan the complementary 3D surface of hand. The scanner is equipped with four measuring heads, which are assembled on a sliding fixture each in different directions, projecting from above, underneath and the left and right sides of the hand. The resolution of the scanner is about 1 mm  $\times$  1 mm  $\times$  1 mm, measurement accuracy of  $\pm 0.4$  mm, the scanning time of 5 seconds.

The scanned surface data will be captured using the measurement editing software (Beauty 3D, Logistic Tech, Taiwan) to repair holes and complementary data.

### 2.3 3D printer

A 3D printer (Tree Maker, Taiwan) was applied to print the customized handle. The print range is 200 x 200 x 200 mm, and the minimum layer thickness is 0.1 mm, nozzle diameter of 0.4mm. All the handles were manufactured with a 3D printer using white ABS plastic with a smooth surface finish. Figure 2 is an example of the printed customized handle.

The customized handle in this study was first gripped by each participant, whether the hand was fit, and the surface was fine-tuned and repaired for customization.



Figure 1. The acquirement of the complementary 3D surface of hand



Figure 2. The printed customized handle

## 2.4 Subjective comfort rating

The participants were introduced about the experiment procedure. They were asked to sit comfortably with elbow at 90 degree and wrist in neutral positions. They were asked to hold the customized handle for 1 min using their preferred normal grip-force. In this way, a standardized and more generalized simulation of a common task using hand-tools was performed. The participants were asked to finish a subjective questionnaire (adopted from [15]) of comfort rating soon after gripping the handle. The participants rated each handle's comfort descriptions and overall comfort-rating on a scale containing 7 discrete levels based on their perceived subjective responses for each handle.

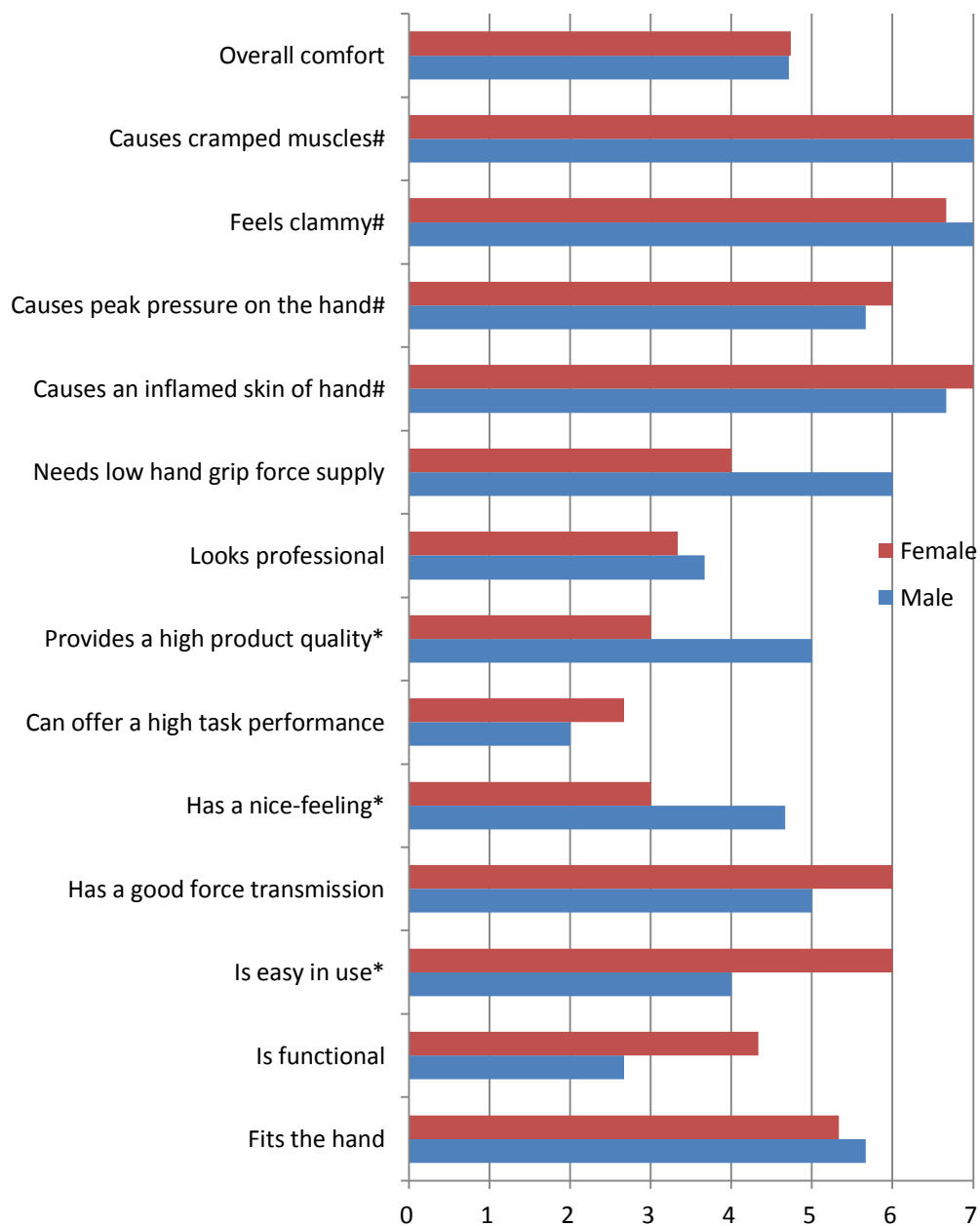
## 3. Results

The mean and standard deviations were calculated based on the data obtained from the subjective comfort-rating questionnaire. Dependent samples T-test was conducted to examine whether there was a significant difference between male and female gender.

The mean values of subjective comfort-rating based on gender were showed in Figure 3. Figure 3 showed that the participants were generally satisfied with their own customized handle, in spite of some comfort descriptors: 'Is functional', 'Has a nice-feeling', 'Can offer a high task performance' and 'Looks professional'. The possible reason is that the customized handles were look different from the traditional handles. The participants were all stranger to the new type handles. They could not recognize how to use

the tool handle to perform the work well, and give a low score for 'functional', 'nice-feeling', 'performance' and 'professional'.

The T-test revealed that comfort descriptors were generally not significant difference between different genders. Only three comfort descriptors: 'Is easy in use', 'Has a nice-feeling' and 'Provides a high product quality' are statistically significant difference at the  $p < 0.05$  between the two genders. The first one descriptor was rated higher from female, and the last two descriptors were rated higher from male. This can be explained by the male might like the new type of appearance, but doubt about the ease of use.



\* The comfort descriptors were significant different between the two genders.

# The comfort descriptors were reverse to postive side.

Figure 3. The mean values of subjective comfort-rating

#### **4. Conclusion**

This paper attempted a different approach to tool-handle design. The customized handles were developed based on 3D surface scanner and 3D printer under power-grasp posture. The maximum grip-force can be exerted that can increase the user performance while using the handles designed with optimal handle sizes [16]. Subjective comfort-rating based on the subjects' preferences regarding grip-diameter size is also increased since there are small deviations [17]. This study proposed the direct development of tool-handles with anatomical shapes and sizes that increases the maximum voluntary contraction of fingers, maximizes the contact area, and lowers the local and overall contact pressures, and increases the subjective comfort-rating. The further study will discuss the effects of some physiology indicators about the use of customized handles.

#### **5. Acknowledgments**

This research was financially supported by the Ministry of Science and Technology under Grant NSC 105-2221-E-233-002. The authors also want to thank the members of the Human Factors Laboratory of Ta-Hwa University of Science and Technology for their assistance with this study.

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## Building Thermal Environment and User Adaptation in a Meditation Retreat in Khon Kaen, Thailand

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### Abstract

Building users are known to have the ability to adapt themselves to certain surrounding thermal environments. Thus, the adaptive model of thermal comfort was developed to reflect such condition. In the adaptive model, physiological acclimatization and behavioural and psychological adaptations are main factors influencing human thermal comfort. The field investigation discussed in this paper investigated the behaviour of meditators with respect to environmental adjustment. The study conducted on 6th of April from 8.00 am to 6.00 pm in the meditation retreat in Khon Kaen, Thailand included measuring thermal environment, evaluating personal variables and observing occupants' environmental adaptation. In terms of the environmental measurements, thermal variables were measured by calibrated instruments complying with Class II standard classified by DeDear et al. (1997). Moreover, personal variables of the occupants were observed and evaluated. Such measuring and observing results will be compared with the neutral temperature and standard values stated in ASHRAE (2010). Furthermore, modification of adjustable environment such as windows, curtains and ceiling fans was observed, illustrated and analysed alongside with the derived thermal factors, while the locally cultural context was preserved throughout the observation. Finally, the research revealed that in most scenarios, existing average indoor operative temperature and outdoor dry bulb temperature were out of the 80 percent of the acceptable zone. Such thermal unpleasant tends to trigger human behaviour to improve room thermal condition. Furthermore, windows were fully operated during the observation time, whereas the ceiling fans were consciously applied during engaging the sessions. Additionally, a pattern of curtain operation was also related to a ratio of practicing area per person.

**Keywords:** *Adaptive Model, Behavioural Adaptation, Environmental Adaptation, Meditation Building.*

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### 1. Introduction

A steady-state model of thermal comfort was derived from a climate chamber study where personal and environmental factors were constantly and carefully controlled. The result of the investigation became international standards such as ASHRAE standard-55 and ISO 7730, which aim to provide building occupiers with ideal thermal comfort. Such standards described a solution of thermal comfort prediction as PDD (Predicted Percentage of Dissatisfaction) and PMV (Predicted Mean Vote) to provide a range of comfort temperature in designed spaces. Such comfort condition as deterministic perspective required high



operational cost and energy consumption from air conditioning system to constantly maintain indoor thermal pleasant.

On the other hand, such constant thermal environment is rarely found in actual contexts where environmental factors such as temperature and humidity vary dynamically and personal factor such as clothing and activity are individually diverse. Humphreys (1978) conducted a meta-analysis on data derived from field studies of human thermal comfort worldwide and the result showed noticeably different trends of regression lines of outdoor air and indoor comfort temperatures which are exponential and linear trends in air conditioned and free-running buildings respectively. Human perception in the latter ventilation type presented a strong relationship between indoor and outdoor temperatures which comfort temperature range is wider than that of the former ventilation type.

Moreover, a series of researchers such as Humphreys (1975), DeDear and colleagues (1997), Brager and DeDear (1998), Nicol and Humphreys (2002), Nikolopoulou and Steemers (2003), Feriadi and Wong (2004) and Yao et al. (2009) reported inaccurate predictions of PMV and PDD when compared with results derived from studies in free-running buildings and urban open spaces. Failures of the estimations result from unexpected factors existing on sites which the steady-state model could not entirely cover. That inaccuracy led to persevering in exploring alternative solutions to improve human thermal comfort, gain more understanding in human thermal perception and decrease excessive energy demand of air conditioning system. Consequently, an adaptive model was purposed and such approach allows building users to occupy spaces with managerial flexibility on their personal and environmental aspects. Moreover, three key adaptable aspects were purposed which focus on physiology, psychology and behavior (Brager and DeDear 1998). According to the adaptive approach, human's adjustability was discussed and thermal comfort might not be solitarily affected by thermal variables, but also non-thermal variables such as cultures, rules, past experience and exposure length ( Knez and Thorsson 2006 and Knez et al. 2009;).

Although the past researches presented the enthusiastic in investigating human adaptation in thermal research worldwide, there is a small number of human thermal comfort research in Thailand. Under such insufficiency of research availability, Thai Green Building Institute (TGBI) purposed TREES (TGBI 2010) as national design guideline based on ASHRAE standard. However, due to different climate and surrounding, such international standard might not be suitable for the local context. Until now, some spaces such as office (Busch 1990), educational (Khedari et al. 2000; Yamtraipat et al. 2005), residential (Jitkhajornwanich 2006; Rangsiraksa 2006 and Nuntasiri and Rasisuttha, 2015) and outdoor spaces (Jitkhajornwanich 1997 and Srivanitand and Auttarat 2015) were investigated. However, the available results were not enough to be confidently concluded and applied as the national standard. Consequently, thermal comfort investigation in this region is urgently required. Thus, more studies in different groups of people, contexts, building types and ventilation systems are required.

In addition, as far as the fast growing number of meditators in Thailand is concerned, the proportion of the meditators has been gradually increasing from 12.17 to 35.50, 40.49 and 45.33 percent amongst the population of 23, 50, 53 and 54 million people in 2005, 2008, 2011 and 2014 (National Statistic office of Thailand (NSO) 2005, 2008, 2011 and 2014). Such interest in meditation, moreover, is not a national phenomenon, but also becomes the global enthusiastic. Meditative activity was firstly introduced in western culture in 1950s and became an attention in medical research in 1960s (Keng et al. 2011). Nowadays, a series of researches confirm benefits of meditation on human bodies (Bagchi and Wenger 1957,

Fennell et al. 2016 and Ospina et al. 2007) and mind (Baer 2003, Walsh and Shapiro 2006, Treadaway and Lazar 2009 and Keng et al. 2011). However, there is no evidence of human thermal comfort study or relevant aspect conducted in this building type although the meditators might spend a long period of time practicing inside the buildings. Consequently, this building type should be crucially investigated in order to understand users' behavioral interaction to thermal surrounding and built environment in this building type under particular cultural and social conditions.

## 2. Literature Review

### 2.1 Neutral Temperature and Acceptable Range of Indoor Temperature

Brager and DeDear (1998) mentioned that PDD and PMV solution is impractical to apply in architectural design process since personal information of clothing insulation value and metabolism rate are varied and unclear in real world situations. Later, ASHRAE issued a newer revision of ASHRAE standard (2004) based on RP-884 database including field study results of human thermal comfort in free-running building conducted globally such as in Australia, the UK, Pakistan and Thailand (DeDear et al. 1997). The revised standard included an alternative expression of comfort zone as a relation of neutral temperature ( $T_n$ ) and mean monthly outdoor temperature ( $T_{o.av}$ ) as Equation 1 with 80 and 90 acceptable zones as Figure 1. However, the purported acceptable zone is limited in a range of outdoor air temperature between 10-33.5 °C.

$$T_n = 17.0 + 0.38 T_{o.av} \quad \text{----- (1)}$$

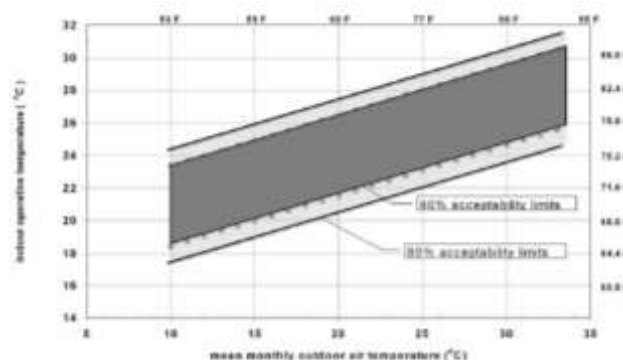


Figure 1: Relation of Indoor Operative Temperature (°C) and Mean Monthly Outdoor Temperature (°C)

### 2.2 Relevant Modes of Human Thermal Adaptation

The adaptive model comprises of three modes of adaptations; however, this report might focus mainly on behavioral adaptation to thermal stimuli. Brager and DeDear (1998) expressed that behavioural adjustment can be categorised into three key aspects which are personal, environmental or technological and cultural adjustments. The first factor relates to personally modifiable variables such as clothing, foods and drinks or posture. Additionally, the second aspect, technological and environmental factors, focuses on operations of operable devices such as windows, curtain, electric fans and air conditioning system, whereas cultural adjustment considers policies, rules, schedules or custom existing in the context such as providing suitable working schedule, short breaks and proper dress codes.

According to investigations of the behavioural adaptation, Indraganti (2010a, 2010b and 2011) conducted a human thermal comfort research in mixed-mode, naturally ventilated and air conditioned residential buildings in India during summer and monsoon seasons and

thirteen questions pertaining to behavioural interactions on thermal stimuli were asked which are sleeping, performing lighter activities, changing gesture, sitting on the floor, living in high air speed area, avoiding exposing to the solar radiation, avoiding staying near high radiant surfaces, employing hand fan, reducing insulation value of clothing, tying hair, taking a bath or shower, drinking or eating cold foods and drinks, moving to more comfortable. According to the result, users' behavioural adaptation varied according to seasons which actions of adaptation were noticeably reduced in monsoon season and the most popular adaptive solutions performed by the occupants were sitting in the airy area and consuming cold drinks.

The behavioural adaptation, moreover, is conducted under opportunity and constraint factors. Such factors were summarised in four main aspects which were climates, economics, building designs and organizational conditions (Brager and DeDear 1998). For climate factor, people in mild climate tend to have a greater opportunity in adaptation than those living in the extreme climate which a combination of solutions to maintain comfort condition might be required. In addition, Parsons (2002) mentioned an influence of hot and cold environments on human behaviour and clothing insulation property of users. In cold conditions, a capability of clothing adjustment depends on designs of the clothing and acceptability. In contrast, the capability of clothing modification is limited by acceptability and suitability in hot environments. In terms of economic aspect, Indraganti (2010) reported that a range of comfort temperature varies inversely with personal income. Higher income earners presented 2K lower in terms of comfort temperature comparing with rest of the samples due to thermally comfortable addiction so called '*thermal indulgence*'. In addition, Feriadi and Wong (2004) conducting a human thermal comfort research in Jakarta, Indonesia showed an agreement with that statement and exemplified that the majority of people residing in developing countries could not afford air conditioning system due to the economic constraint. Therefore, they tend to be more tolerable on uncomfortable thermal conditions in absence of thermal pleasant. However, such constraint is different in developed countries where the operational cost of thermal regulation is normally acceptable and always included in construction (Brager and DeDear, 1998).

Furthermore, behaviourally adaptive action can be influenced by architectural design. Day et al. (2012) reported a consequence of obstruction of interior furniture causing inaccessibility of adjustable environments and that difficulty can be considered as the adaptive constraint of thermal adaptation. Parsons (2002) described that poor building design and lack of personal control contribute to a negative impact on human thermal evaluation as such conditions limit occupiers' adaptive capability. Likewise, Luo et al. (2016) conducted a research to investigate effects of perceived control on human thermal perception and mentioned that such psychological aspect leads to differences of individual thermal evaluation; for example, providing enough personal controls such as operable windows, fans and curtains possibly reduce thermal occupiers' dissatisfaction.

Perceived control, on the other hand, is not only availability of operable elements of the building, but also space ownership. Indraganti and Rao (2010) reported that the latter factor is psychological influence contributes to a greater capability of environmentally perceived control. Moreover, O'Brien and Gunay (2014) agreed with the existent of such factor and mentioned that people in shared space might have a weaker sense of such perception owing to timidity. For instance, open-plan offices which are supposed to possibly achieve cross-ventilation might have less efficiency of natural ventilation than those privately partitioned working spaces owing to loss of perceived control on operable building elements (Dorn and Schnare 2013 cited in O'Brien and Gunay, 2014). Similarly, organization and social norm

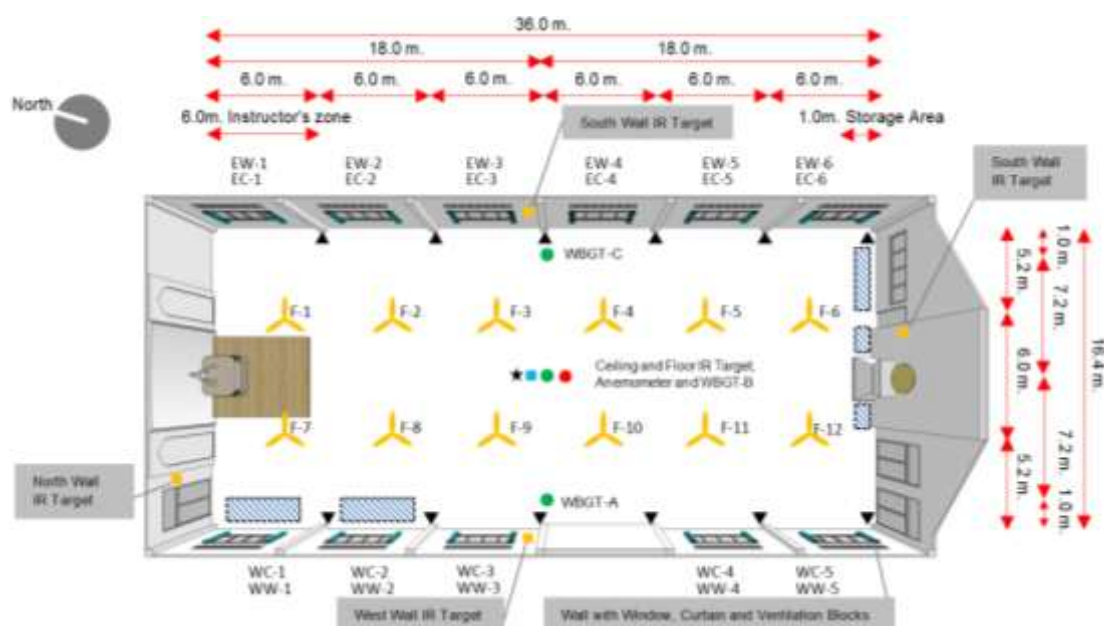
possibly encourage human to thermally adapt in spaces such as providing opportunity to select their suitable or adaptable clothing rather than wearing unmodifiable uniform or to relocate to thermally pleasant places during working hour; likewise, impact of energy conservation campaign or government policy can influence behaviourally adaptive activities (Brager and DeDear 1998).

### 3. Methodology

This field study aims to explore a current thermal environment and to observe human interaction to the built environment under particular culture and social conditions of meditation retreat by applying quantitative method which is measurements of physical of thermal environment of the room and qualitative method which is an observation of behavioural interaction on modifiable built environment. The research started from 8.00 am to 6.00 pm on 6<sup>th</sup> of April 2016 was conducted on the 1<sup>st</sup> floor of a meditation building in Khon Kaen, Thailand. Normally, the meditation retreat organizes 4 sessions started from 4.00 am to 9.00 pm daily. During the study period, the room held two meditative sessions which were session 2, 8.00-10.00 am, and session 3, 1.00-4.00 pm. The number of participants was varied in each session. During the observation, measuring instruments recorded manually and automatically every 30 minutes. Clothing insulation values (CLO) and metabolic rates (MET) were referred to ASHRAE standard-55 (2010). Moreover, patterns of environment modifications such as windows, curtains and ceiling fans were observed and recorded in the same time interval.

#### 3.1 The Practising Room

The studied room is located on the 1<sup>st</sup> floor of a meditation building which was designed as an L-shape layout surrounded by green area at the South and West façades and the North and East sides of the building expose to a large open space. The main structure of the building is a concrete frame structure which can be divided into two main parts which are north and south parts. The south part is a three-storey structure comprising a common area on the ground floor and the other stories are a residential area for the participants, while the north wing is a two-storey structure comprising multi-purpose room on the ground floor and meditation room on the first floor. For this research, the latter room was used as a case study.



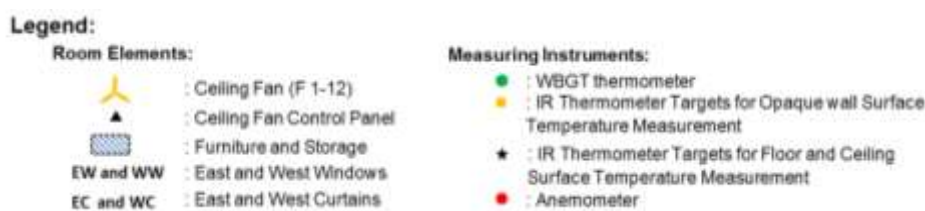


Figure 2: A Layout of the Practising Room with Dementions and Locations of Measurement

The studied room is a large shared space which dimensions is 35.9 by 16.4 meter and exposed to the attic. Besides, twelve ceiling fans were installed and accessible control panels were available at the columns as Figure 2. The ceiling of the room was designed as cathedral style which maximum and minimum heights of 5.70 and 3.5 meter. The gross room area is 590.4 square meter, but practicing area for meditators is 475.6 square meter since 6 meters from the north wall is the area for meditation instructors and 1 meter from the south all is for storage and circulation. Moreover, the East and West sides of the room are external walls comprising 11 sliding windows with curtains and ventilation blocks located over the windows. The window dimensions are 3.20-meter length and 1.10-meter height placed at 1.00 meter above the floor and exposing to the external environment without shading devices.

### 3.2 Environmental Measurements and Measuring Instruments

The measurements of thermal variables of the environment applied in this research are Dry Bulb Temperature (DBT), Globe Temperature ( $T_g$ ), Relative Humidity (RH), Wind Speed (V), Surface Temperature ( $T_{ir}$ ). Such thermally environmental variables will be applied to calculate for Mean Radiant Temperature (MRT) and Operative Temperature ( $T_{op}$ ) before the results are compared with the acceptable operative temperature zones as mentioned in ASHRAE Standard-55. Moreover, instruments used in this research were categorised as Class II by instruments classification purposed by Brager and Dedear (1998).

For DBT,  $T_g$  and RH measurements, four devices of Lutron WBGT 2010 SD thermometer were selected and named as WBGT A, B, C and D. The instrument accuracies are varied according to measured variables which DBT,  $T_g$  and RH are  $\pm 0.8^\circ\text{C}$ ,  $\pm 0.6^\circ\text{C}$  and  $\pm 3\%$  of the measured results. To measure surface temperatures, two devices of Lutron Tm 969 infrared thermometer were selected with accuracies of  $\pm 0.1^\circ\text{C}$  for 1:50 distant to measurement spot ratio. Moreover, model TA 411 DA of Tasco with a dumbbell-type probe was selected with  $\pm 5\%$  measuring accuracy for air velocity measurement. All instruments were calibrated by authorized laboratories before applied in the observation.

Furthermore, three standard measuring heights for sitting posture were initially referred to ASHARE standard-55 (2004). However, such levels could not be complied with for this context since meditative activity normally performs close to the floor level. Thus, the measuring level for this group of people was set at 0.4 m as the level of human's body. For installation locations of the instruments, WBGT-D, were placed outside at the north side of the building in shaded area, while the other three WBGT thermometers, WBGT A, B and C, were placed indoor which WBGT B was located at the centre of the room with the anemometer, while the WBGT A and C were installed at 1 meter away from the East and West walls as Figure 2 presenting.

Due to unpredictability and fluctuation of the prevailing wind, wind velocity was measured by a range of wind speed during 6 minutes of each 30-minute interval which was 3 minutes before and after the measuring time. Thus, three different magnitudes were derived and converted to average indoor wind speed (ID-V). For surface temperature measurements, four

different orientations of the internal walls were measured at three levels which are 0.4, 1.65 and 2.9 meters. Each height of the measuring point was controlled by an A3-size target with a 20 cm-diameter penetration exposing to the wall surfaces. Furthermore, surface temperatures of the ceiling and floor were measured at the WBGT-B location by applying the same measuring method of the wall surfaces.

### 3.3 Personal Variable Evaluation and Cultural Condition Conformation

Uniforms of the meditators were provided by the meditation retreat. the male uniform is a light short sleeve t-shirt with light cropped trousers, while that of the female is a light long sleeve t-shirt light long skirt and a breast scarf as **Figure 3**. Thus, estimated CLO of male and female practitioners are 0.38 and 0.45. Moreover, the meditators will perform similar activities such as sitting and walking meditations during engaging the sessions. Such metabolism rate (MET) of the meditative activities can be considered as sedentary activities which refer to 1.0 and 1.2 for sitting and walking meditations. Moreover, a period of sleeping and resting time and consumption of foods and drinks were equally controlled by the centre.



**Figure 3: Meditation Uniform of Male (Left) and Female (Right)**

As this research was conducted under locally cultural conditions, it is important to understand their rules before conducting the research. There are two major rules which all participants must abide by which are '*precept 8*' and training rules. For the former rules, the practitioners will apply three extra precepts which are abstaining from having foods after 12.00 am, seeing entertainments, using perfume and sleeping or seating in high and luxurious beds and seats, while normal Buddhist apply '*precept 5*' which are 5 fundamental rules. With regard to the training rules, the participants are required to abstain from communications whether by writing, reading, talking, listening to the radio and smoking. Meditating locations in the room will be initially organized by the meditation instructors; however, such positions can be changed if the participants consider unsuitable for the practise. In terms of the behavioural observation on the environmental adaptation, patterns of window, curtain and ceiling fan operations are monitored and considered as an evidence of physical trace of occupiers' activities. Thus, the research assistants were instructed to aware of such contextual condition and strictly conformed to the local rules.

## 4. Results

### 4.1 Measurements of Thermal Environment

With regards to indoor wind speed measurement (ID-V), ID-V was relatively fluctuated and unpredictable as a nature of natural ventilation. The highest air speed, 0.54 m/s, was found after finishing session 2 at 10.30 am with 0.25 m/s standard deviation (SD), while the lowest speed of wind was 0.07 m/s with 0.035 m/s SD at 5.00 pm. According to the measurement, average ID-V when the fans were operated was 0.38 m/s SD of 0.12 m/s. When the room was unoccupied, average indoor air speed dropped to 0.14 m/s with 0.06 m/s SD as Figure 4.



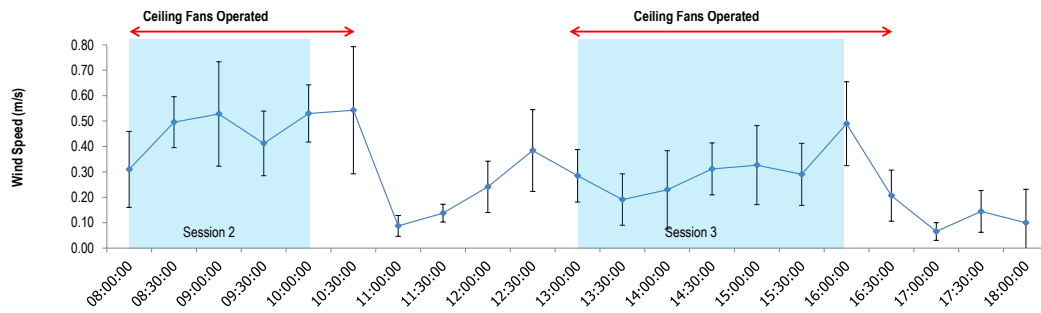


Figure 4: Average Indoor Wind Velocity (m/s)

Furthermore, Figure 5 presents a relationship of average indoor dry bulb temperature (ID-DBT), average indoor globe temperature (ID-TG), average indoor relative humidity (ID-RH), average indoor operative temperature (ID-TOP) and outdoor dry bulb temperature (OD-DBT). The lowest OD-DBT was 29.70 °C, while average ID-DBT was 31.51 °C at 8.00 am. Then, OD-DBT gradually increased to reach the maximum temperature at 4.00 pm at 37.66 °C, while ID-DBT was slightly lower as 37.27 °C. The magnitudes of ID-DBT and ID-TG presented a small difference; thus, a result of ID-TOP calculation is identical to ID-TG showing overlapping trend lines and slightly lower than the trend line of ID-DBT. Thus, according to the measurements, the range of ID-TOP is 31.50 – 37.66 °C and that of ID-RH is 24.03-48.23 % as Figure 5.

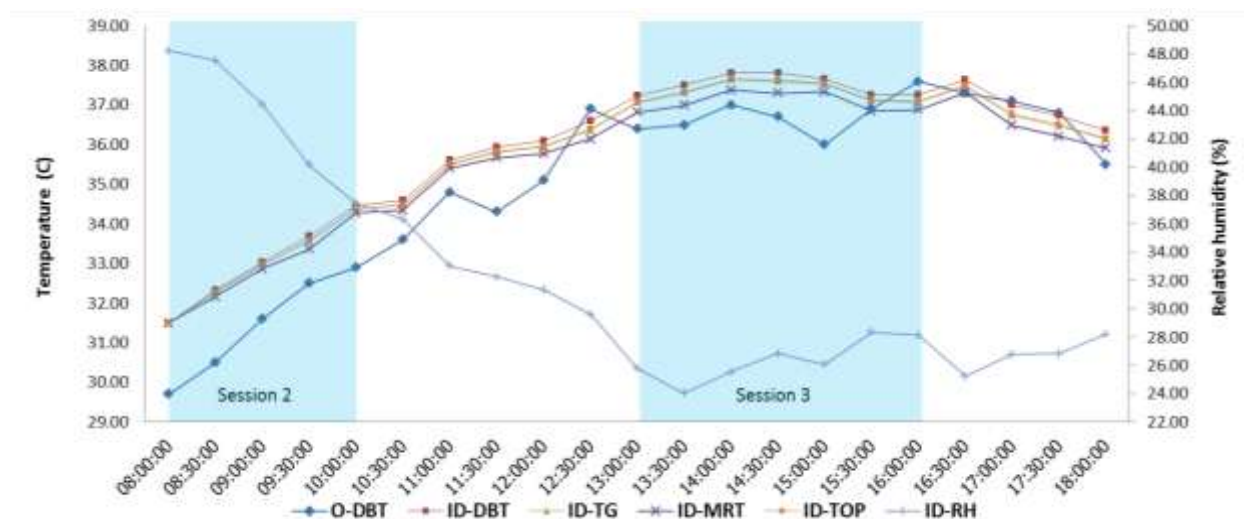


Figure 5: Comparison of Indoor and Outdoor Temperatures (°C) and Relative Humidity (%)

In terms of the surface temperature measurement, the ceiling accounted for the hottest surface in the room which was 43.8 °C at 1.00 pm when OD-DBT and ID-DBT were 36.40 and 37.23 °C. The lowest surface temperature, in contrast, was the west wall which was 31.13 °C at 8.30 am when OD-DBT and ID-DBT were 30.50 and 32.33 °C as Figure 6 presenting.

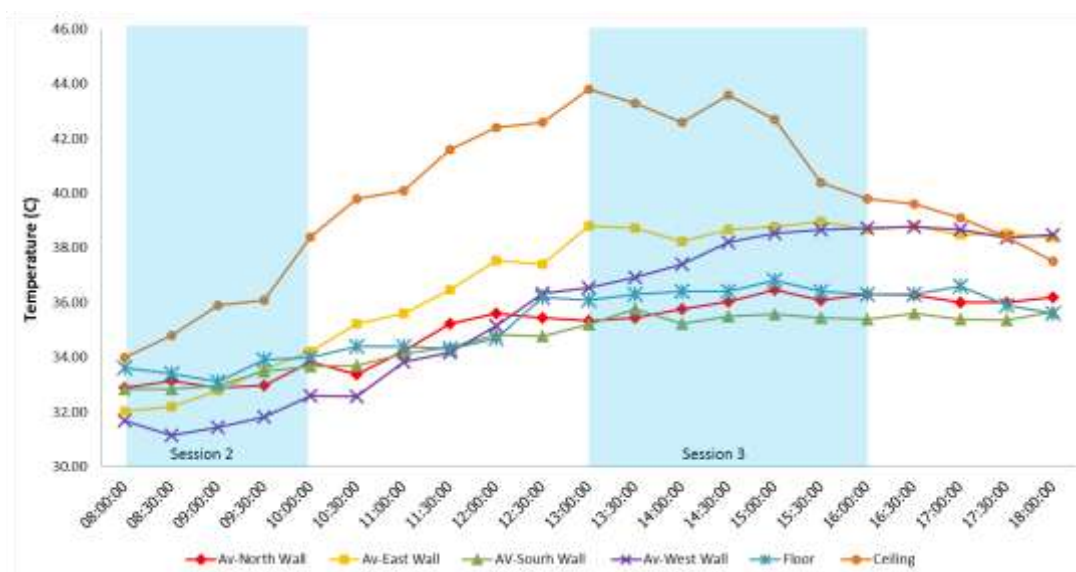


Figure 6: Comparison of Internal Surface Temperatures (°C)

Moreover, the ceiling surface presents the greatest variation of surface temperature which a daily average of surface temperature was 39.95 °C with 2.98 SD as Figure 7. On the other hand, the south wall which was an interior partition showed the lowest surface temperature which daily average of surface temperature was 34.65 with 1.02 SD.

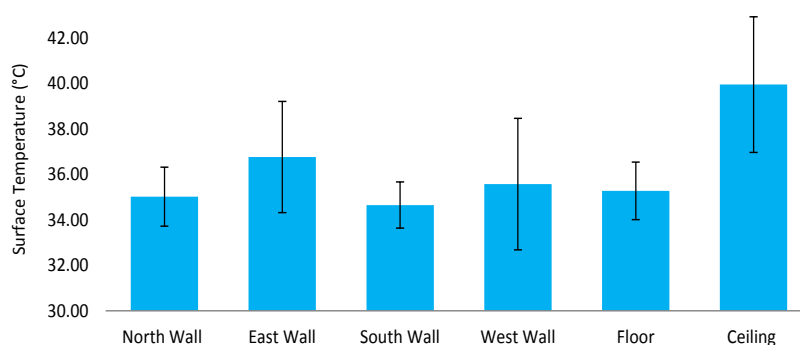


Figure 7: Average Indoor Surface Temperature (°C)

#### 4.2 Evaluation of Existing Thermal Environment as ASHRAE Standard-55

The measuring information was analysed and compared with neutral temperature, 80% and 90% acceptable zones purposed by ASHARE Standard-55 (2010). The maximum and minimum OD-DBTs as included in the standard range from 10 – 33.5 °C. Such range can lead to 17.3 – 24.3 °C range for 80% acceptable ID-Top of the lower outdoor temperature limit, 10°C, and 26.23-33.23 °C of 80% acceptable ID-Top of the upper outdoor temperature limit, 33.5°C. According to the graph, in most cases of the observation, occupants might suffer from the hot condition of the room as ID-Top after 9.30 am was laid outside 80% acceptable zone. On the other hand, possible comfort condition for this room during the observation was found before the 2<sup>nd</sup> session started until 9.30 am as Figure 8.



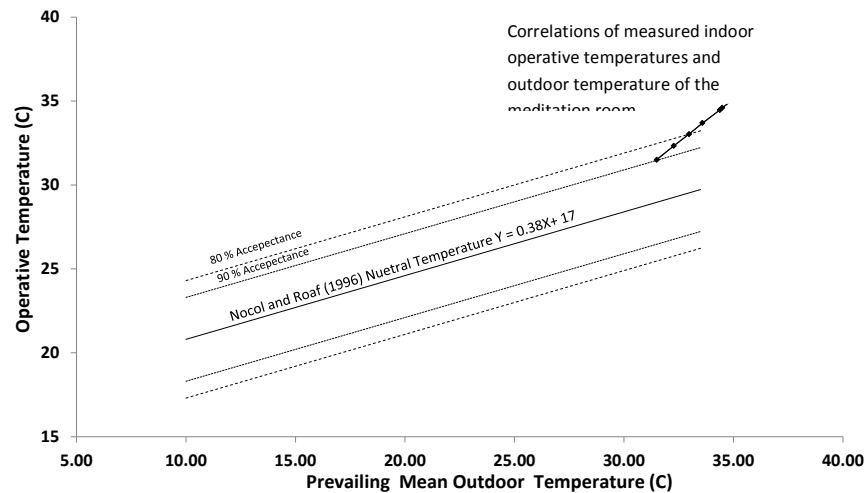


Figure 8: Comparison of Acceptance of indoor Neutral Temperature (°C) and Current Thermal Situation of the Room (°C)

### 4.3 Number of participants and Observation of Human Environmental Adaptation

In each session, there was a variation of the number of meditators. In the morning session, 107 meditators engaging the 2<sup>nd</sup> sessions led to a low ratio of practicing area per person,  $4.44^{Sq.M.}/_{Person}$ . However, there were new meditators joining the activity in the afternoon session and the room could not accommodate all the participants; thus, the meditation instructor asked the meditators for volunteering to move into the common area on the ground floor. Thus, in this session, 64 people occupied the room which that attendance results in the higher ratio which is  $7.09^{Sq.M.}/_{Person}$ . Moreover, operation patterns of adjustable windows, curtains and ceiling fans were observed and illustrated in Table 1.

Table 1 : Operation Schedule of Windows, Curtains and Ceiling Fans

(Legends: 1.0=Fully Operated, 0.5 = 50% Operated and 0.0 = Closed or Turned Off)

		Window (W) and Curtain (C) Schedules																				Fan Schedule (F)													
		East Walls (W) and Curtin (C)								West Walls (W) and Curtin (C)								Ceiling Fans (F)																	
Time	Session	EW-1	EC-1	EW-2	EC-2	EW-3	EC-3	EW-4	EC-4	EW-5	EC-5	EW-6	EC-6	WW-1	WC-1	WW-2	WC-2	WW-3	WC-3	WW-4	WC-4	WW-5	WC-5	F-1	F-2	F-3	F-4	F-5	F-6	F-7	F-8	F-9	F-10		
08:00:00	Session 2	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	
08:30:00		1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
09:00:00		1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
09:30:00		1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10:00:00	Break	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
10:30:00		1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
11:00:00		1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
11:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12:00:00	Session 3	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
12:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
13:00:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
13:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
14:00:00	Break	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
14:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
15:00:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
15:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
16:00:00	Session 3	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
16:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	
17:00:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	
17:30:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	
18:00:00		1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

According to Table 1, all the sliding windows were always fully open throughout the observation. In contrast, the fans were turned on with maximum power while engaging the sessions and turned off after finishing the training sessions. However, patterns of the curtain operations between two sessions are different. The devices were operated according to directions of solar radiation. For example, the East walls and windows of the room faced directly with solar radiation in the morning. One solution that possibly addresses this problem was to block such energy by manipulating the curtains. In this sample, five curtain sets, EC-2, EC-3, EC-4 and EC-5 and EC-6, were closed. On the other hand, when the sun moved to the west side of the building, operation of curtains changed accordingly. However, in the afternoon, a trace of adaptation on modification of curtains was less noticeable as there were two sets of curtains, CC-1 and CC-2, modified although the operative temperature was high. After the users finished each session, all of the curtains were turned to fully open again. In terms of hours and percentage of operations, the sliding windows were always applied throughout the study which was 10 hour or 100 % of the observation period. On the other hand, an average hour of the fan operation accounted for 6 hours 12 minutes, 62.00% of the observation period with 4.83% SD. In contrast, curtains presented minimal operation, 2 hours 12 or 23.33% with the highest 28.76% SD.

**Table 2: Comparison of Hours and Percentage of Operation of Modifiable Devices**

	<b>Average Hours of Operation</b>	<b>% of Operation</b>	<b>SD of Operation</b>
<b>Window</b>	10 hrs	100.00	0.00
<b>Ceiling Fan</b>	6 hrs 12 mins	62.00	4.83
<b>Curtain</b>	2 hrs 18 mins	23.33	28.76

## 5. Discussion

According to ASHRAE standard, the room seemed not be able to provide thermal comfort condition to the occupiers during the observation although environmentally adaptive solutions were applied. In terms of radiant temperature, due to the practicing room is located on the first floor where the practicing space exposed directly to the attic, the average surface temperature showed that ceiling surface temperature was critical as presenting highest average heat radiation which was 39.83 °C, while the south wall presented the lowest average surface temperature which was 34.65 °C during the observation. The ceiling surface seemed to create thermal dissatisfaction due to vertical radiant temperature asymmetry which the maximum temperature difference between ceiling and floor surfaces was 7.7 °C at 12.00 am, whereas the standard suggests maximum 5°C difference for those surfaces (ASHRAE-Standard-55 2010).

In terms of the operations of the operable building elements, the ceiling fans were intelligently and carefully run only during engaging the sessions; in contrast, the windows were applied to induce natural ventilation throughout the observation. In terms of curtain works, a pattern of such operations in session 2 and 3 was relatively different. The curtains in this context can be considered as an operable shading device which operates under 4 conditions which are a position of the sun, accessibility to control area, impact location of the radiation beam on and practicing area per person ratio. According to the study, sun path is an influential factor as the occupiers can perceive the movement of the sun resulting in stimulating human reaction on the curtains accordingly. Additionally, although the room provides operable devices for thermal adaptation, some instruments might not be effectively

operated due to a difficulty of accessibility such as a sample of CW-1 which was always 50% open due to furniture obstruction. Moreover, it should be noted that curtains will not be modified if occupied areas are not affected by the radiation beam. For example, solar radiation shining through EW-1 on the unoccupied area at the instructor's zone might not directly disturb the meditators; thus, EC-1 was left opened throughout the observation as Table 1 showing.

Besides, the operation pattern is affected by the ratio of practicing area per person. In this context, the practicing room is a shared space where privacy and perceived control of occupants were minimal (O'Brien and Gunay 2014). Personal adaptation such as increase of exposing body surface area or choosing lighter clothing insulation value might be considered as an improper solution in this context, whereas environment adaptation can be performed modestly under local organizational and cultural constraints. In the morning session, 107 occupants engage the activities; as the result, the practicing area per person ratio of the room was 4.44(Sq.M.)/Person. Such minimal ratio resulted in a limit opportunity of relocation which prohibits users from avoiding direct solar radiation exposure or staying in airy area. Therefore, an available option of environmental adaptation in the morning session was modifying the curtains. In contrast, in the afternoon session, the practising room was less dense which the ratio increased to 7.09 (Sq.M.)/Person. The meditators had more options to choose whether they would reposition to avoid exposing to direct solar radiation or to maintain their location while operating the curtain as a shading device. As the result, it seems that modifying the environment might not be preferable in this context if the personal adaptation can be conducted. Thus, the curtain operation pattern in the afternoon session showed a small change comparing to the morning operation. Consequently, it can be implied that ratio of practising area per person tends to influence operation pattern of the curtains and personally perceived control in terms of relocating capability. For the future research, a wider range of indoor temperature and human behaviour in different types of building and ventilation types should be examined together with investigating subjective vote of thermal comfort for this group of people. Besides, although this research presents the detailed results of human environmental adaptation, investigation of personal adjustment should be focused and compared with this study in order to gain more understanding and explore the most common solution of human behavioral adaptations.

## 6. Conclusion

The physical measurement of thermal environment of the room reveals that the meditation room was in hot condition during the survey as most of the ID-Top of the study room during the study were out of the 80% acceptable ID-Top range purposed by ASHRAE standard-55. Such dissatisfaction tended to perform as a drive of behavioral adaptation of the meditators. In term of environmental adaptation, the observation reveals that windows were the most frequent utilization of the adaptable devices which present 100% operation throughout the observation and the second frequent use was ceiling fans accounting for 62.00 %. Curtain operation, in contrast, presents the least operation which is 23.33%. The pattern of curtain operation presents the most variation due to 4 factors which are sun path, accessibility to the control locations, an impact location of the radiation beam and ratio of the practicing area per person.

In terms of the ratio of practicing area per the number of participants, it might be concluded that the number of occupants and the working area influence human adaptive behavior and can be considered as one factor of adaptive opportunity and constraint. When the room presents the low ratio of practicing area per person, the occupants tend to lose their capability

of relocation affecting personally perceived control. Consequently, the occupants who remain in their locations where they are potentially exposed directly to solar radiation might require operating curtains to block such excessive energy. On the other hand, if the room accounts for a greater number of the ratio allowing people to relocating freely, the requirement of curtain usages might be reduced, allowing the windows to operate with higher opening areas. Finally, it can be concluded that the ratio of practicing area per person which can be considered as the adaptive opportunity and constraint tends to affect personally and environmentally perceived controls. Moreover, such ratio is an influential factor which possibly affects built environment in terms of operation pattern of curtains in this context.

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## **Classification of Moving Objects in Surveillance Video**

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### **Abstract**

The major task in the smart surveillance system is to classify the moving object blobs into predefined classes. This task is vital as the semantics of the classification helps in understanding and interpretation of high level vision analysis such as object recognition, object behaviour understanding and event detection. In this paper, a moving object classification method is proposed based on features of the object shape. The seven invariant Hu moments features are employed to represent the motion object blob for classification. The suitability of symbolic representation of these feature values for classification of moving objects in particular to inter class classification is studied in this work. The symbolic representation scheme, particularly the interval value based symbolic scheme is used to represent the variations among the classes. The matching of symbolic feature values is performed by applying symbolic similarity measure. The segmented foreground motion object blobs are classified into single person, group of people, two wheeler, small vehicle or big vehicle classes using a simple nearest neighbor classifier. The proposed classification method is experimented on the benchmark DARPA Neovison2 and IEEE PETS datasets. Further, classification accuracy has been ascertained using the F-measure accuracy metric.

Keywords: Object classification, Surveillance video, Symbolic representation, Interval value.

### **1. Introduction**

Object classification is very much essential for the surveillance applications as the scene may consist of rigid (e.g., vehicle) and non-rigid objects (e.g., human). Categorizing the type of a detected object helps to extract semantics from the video sequences which can be used in high level activity analysis tasks. Classification of moving objects is a challenging task specifically in the surveillance video sequence, as the surveillance video sequences are captured from a dynamic environment with occlusions of objects and cluttered background. Further, multi-class classification of objects is difficult due to complex and non-rigid objects (Weiming et al., 2004; Wang and Xiaogang, 2013).

In literature, considerable number of works (Lipton et al., 1998; Javed and Shah, 2002; Zang and Klette, 2003; Hu et al., 2006; Zhang et al., 2007; Dallalazadeh et al., 2012; Zhang et al., 2013; Asaidi et al., 2014; Liang and Juang, 2015) on moving object classification are reported.

Javed and Shah (2002) proposed a method for moving object classification using block based temporal motion features of each object silhouette. Classification is carried out by observing the changes in blocks of the silhouette and then the object is categorized into single person, group of people or vehicles. Liang and Juang (2015) proposed a method to classify the objects into three classes viz., human, car or motorcycle. The histogram of the minimum enclosed rectangle extracted from the domain transformed through HAAR wavelet with hierarchical SVM is used to classify objects. Guru et al. (2012) used a symbolic approach for the classification of moving vehicles in traffic videos into four classes. The normalized shape features extracted from the segmented foreground is represented using symbolic interval values and the moving vehicles are classified respectively. Hu et al. (2006) proposed a method for classification, which classifies objects into three classes namely isolated, group or objects under occlusion with other objects by using vertical projection histogram based on the shape of the segmented motion object. A method proposed by Zang and Klette (2003) uses the ratio of the object's bounding box height to width, for classifying objects into vehicles or pedestrians. Lipton et al. (1998) proposed a method to classify objects into human or vehicle, using object dispersedness metric measured by calculating the ratio of the perimeter to the area of the silhouette of the object. Asaidi et al. (2014) proposed a method for vehicle classification using Hu moments. Zhang et al. (2013) classified moving objects into pedestrians, bicycle or vehicles using shape and motion features of the object. Zhang et al. (2007) used block based local binary pattern extracted from the object bounding box, for classification of the motion objects. Adaboost classifier was used to classify the object into car, group of people, bike, van or truck.

It is evident from the literature that very little work has been reported on the classification of moving objects especially the multi-class classification and is more difficult when multiple categories are desired. Further, most of the methods are based on either features extracted from bounding box such as the ratio of height to width and histogram or the motion features, of the object blob for of classification. Moreover, relying on these features to classify the



motion objects may be insufficient for multi-class classification. Further, the motion features can be only be used to categorize either human or vehicle.

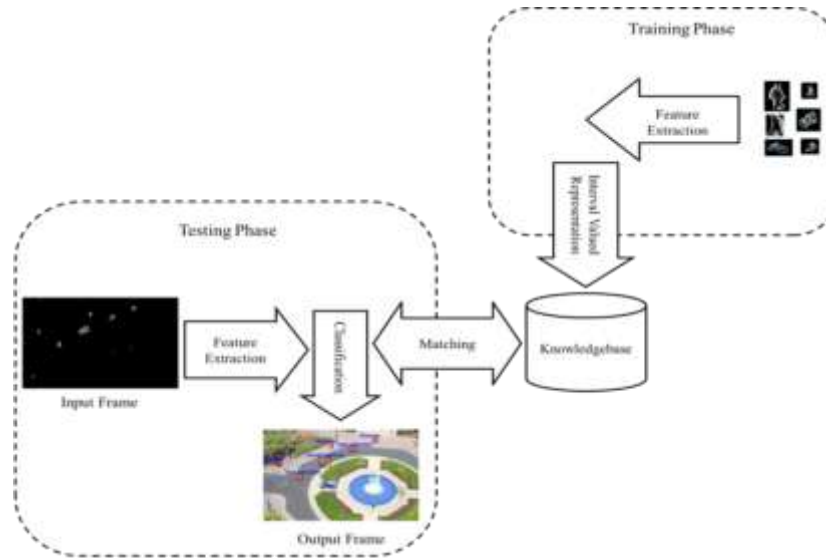
In view of this, an attempt is made in the present work to devise a multi-class moving object classification method using interval valued type symbolic representation of the feature values of the object. The symbolic representation technique is adopted as proposed in the method (Guru et al., 2012), wherein, the problem of vehicle classification in traffic video was addressed. By representing these symbolically it is possible to catch the variations within the feature values for effective classification. As aforementioned, the methods based on shape features are best suited for multi-class classification.

The rest of the paper is organized as follows: The proposed symbolic multi-class classification method is presented in section 2. Experimental results and analysis are reported in section 3 followed by conclusion in section 4.

## **2. Proposed Method**

The block diagram of the proposed method is shown in Figure 1, which depicts the overall procedure for classifying the motion objects into predefined classes viz., single person, group of people, two wheeler, small vehicle or big vehicle. The classification model consists of two phases viz. training and testing. In training phase, the motion objects segmented using motion segmentation algorithm (Chandrajit et al., 2014) will be used as training objects. The seven invariant Hu moments features (Hu, 1962) are extracted for each class of the object and the reference feature values are represented in the symbolic interval valued representation.

In testing phase, the extracted crisp features of the motion segmented object are matched with the feature values which are represented in symbolic interval valued type. Based on the similarity match obtained by the symbolic similarity measure and using the simple nearest neighbor classifier, the object is classified into respective class.



**Figure 1** Block diagram of the proposed classification method

## 2.1 Feature Extraction

Extraction of the relevant features of the objects plays a key role in the classification of the objects in the frames of a video. The features commonly used for representing an object are: (i) geometric features such as area, centroid, major axis, minor axis, orientation, etc. (ii) the features extracted from the object blob region such as color, textures, histogram, ratio of height to width, etc. (iii) the shape features of the object blob such as Hu moments, etc. (iv) the temporal features extracted by observing the consecutive frames of a video.

The choice of features varies depending on the application. In the proposed method, seven invariant Hu moments (Hu, 1962) feature are used for object representation. Thus, the seven invariant Hu moments feature values obtained for the object are recorded in the feature vector  $F_l = \{\phi_1, \phi_2, \phi_3, \dots, \phi_7\}$ , where  $l$  represents the number of objects.

## 2.2 Symbolic Interval Valued Feature Representation

Efficient representation of the feature values in an appropriate form is necessary for achieving a robust classification. Each class of objects such as human, group of people, two wheeler, small vehicle or big vehicle, will have different feature values and these values will be falling within an interval. Therefore, a representation scheme using the minimum and maximum values of each independent feature is suitable for classification. In this section, a symbolic interval valued representation for reference feature values of the objects in the knowledgebase is defined.

Let  $o = \{o_1, o_2, o_3, \dots, o_i\}$  be the  $i$  number of objects; each  $i$  value represent a class to which the object  $o$  belongs. Let  $F_l^i = \{\phi_{l1}^i, \phi_{l2}^i, \phi_{l3}^i, \dots, \phi_{lk}^i\}$  be the  $k$  features describing the Hu moments of  $l^{th}$  object belonging to  $i^{th}$  class.

The minimum and maximum interval among the  $k^{th}$  feature for  $m$  objects of  $i^{th}$  class is given by 1 and 2 respectively.

$$F_{k(min)}^i = \min(\phi_{1k}^i, \phi_{2k}^i, \phi_{3k}^i, \dots, \phi_{mk}^i) \quad (1)$$

$$F_{k(max)}^i = \max(\phi_{1k}^i, \phi_{2k}^i, \phi_{3k}^i, \dots, \phi_{mk}^i) \quad (2)$$

Thus,  $[F_{k(min)}^i, F_{k(max)}^i]$  is the interval representing the  $k^{th}$  values of the feature of objects belonging to  $i^{th}$  class.

Hence, the feature vectors representing the reference object belonging to  $i^{th}$  class is of interval valued type as given in 3.

$$ROF^i = \{[F_{1(min)}^i, F_{1(max)}^i], [F_{2(min)}^i, F_{2(max)}^i], [F_{3(min)}^i, F_{3(max)}^i], \dots, [F_{k(min)}^i, F_{k(max)}^i]\} \quad (3)$$

The symbolic feature vectors representing all the classes of objects such as human, group of people, two wheeler, small vehicle and big vehicle are stored in the knowledgebase.

### 2.3. Classification

Classification of an object into a predefined class is carried out by establishing the similarity between the undefined feature values and the feature values of the predefined classes in the knowledgebase. Since, the interval valued type symbolic representation for feature values are used; a symbolic similarity measure (Guru and Nagendraswamy, 2007) is employed for establishing the similarity between the objects.

Let  $CF = \{CF_1, CF_2, CF_3, \dots, CF_k\}$  be the vector of crisp features extracted from the motion object blob in the testing phase and  $ROF$  be the vector of the symbolic interval valued feature values representing the reference object class as shown in 3. The similarity between  $CF$  and  $ROF$  is measured as in 4.

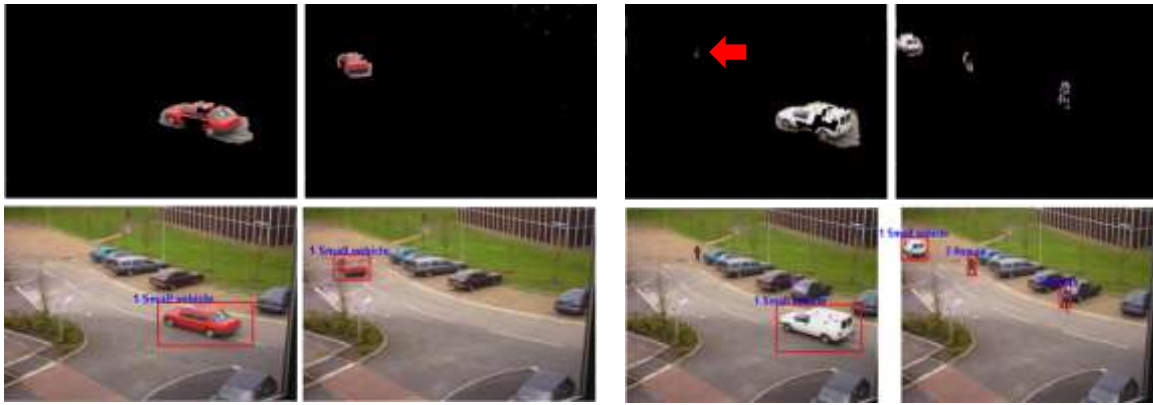
$$S(CF, ROF) = \frac{1}{k} \sum_{l=1}^k \left\{ \begin{array}{ll} 1 & \text{if } (F_{l(min)}^i \leq CF_l \leq F_{l(max)}^i) \\ \max \left[ \frac{1}{1 + \text{abs}(F_{l(min)}^i - CF_l)}, \frac{1}{1 + \text{abs}(F_{l(max)}^i - CF_l)} \right] & (\text{otherwise}) \end{array} \right\} \quad (4)$$

A similarity value 1 is assigned if the corresponding feature value lies between the intervals defined in 3. Otherwise, a maximum similarity value is assigned based on the upper and the lower bounds with respect to the crisp feature value. Hence, the final similarity value is obtained between the test and the reference object considering all the features. A simple nearest neighbour classification technique is used for classifying the given unknown object into one of the reference objects in the knowledgebase. This type of classification is used since the samples in the training phase for identifying the given unknown object as one of the reference object stored in the knowledgebase are small in number.

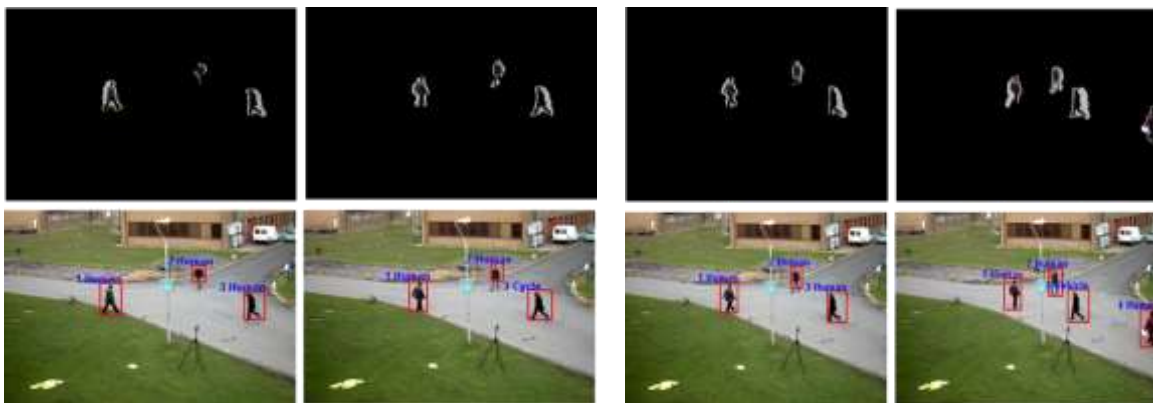
### 3. Experiments and Results

The method is tested on a variety of indoor and outdoor sequences of IEEE PETS (<http://www.cvg.reading.ac.uk/PETS2013/a.html>) and DARPA NeoVision 2 (Kasturi et al., 2014) datasets. The results for PETS 2001, PETS 2013 and DARPA NeoVision datasets are shown in Figures 2 through Figure 4 respectively, where, the top row represents the moving blob generated by the motion segmentation algorithm and the bottom row represents the result of the proposed classification algorithm along with the tracking result.

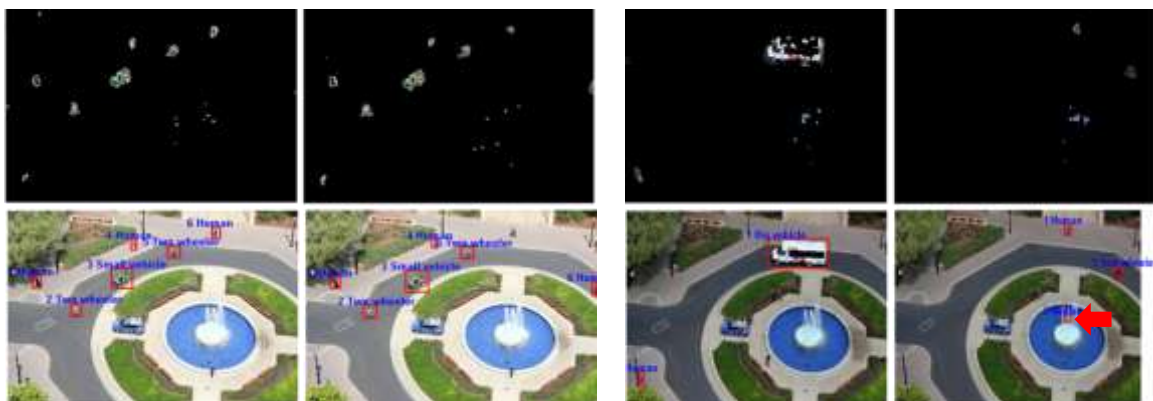
In the top row of Figure 2 (highlighted using red arrow) some motion pixels segmented with small region are not classified. This is due to the constraint imposed on the area for the object. Figure 4 shows an example of a dynamic background. The region of the fountain in the scene is also segmented because of large intensity variations in this region. Further, the shape of the segmented object blob closely matches the shape of the human. Therefore, a misclassification has occurred.



**Figure 2** Sample results of IEEE PETS camera 1 2001 sequence



**Figure 3** Sample results of IEEE PETS 2013 S2 View 1 sequence



**Figure 4** Sample results of DARPA Neovision2 012 sequence

In order to estimate the accuracy of the proposed method, F-measure accuracy metric as defined in equation 5 is used for evaluation. Experiments were conducted by using the training samples in the percentage of 30%, 50% and 70% of the video frames. Table 1 presents the results obtained by the proposed method.

**Table 1** Performance metrics values obtained by the proposed moving object classification method

Dataset Sequence	Training Samples	Precision	Recall	F-measure
IEEE PETS 2013 S2.L1 View1	70%	0.88	0.88	<b>0.88</b>
	50%	0.87	0.86	0.86
	30%	0.87	0.86	0.86
IEEE PETS 2013 S2.L1 View7	70%	1.00	0.73	0.85
	50%	0.91	0.83	<b>0.87</b>
	30%	0.83	0.83	0.83
IEEE PETS 2001 Camera 1	70%	0.92	0.85	<b>0.88</b>
	50%	0.92	0.84	0.88
	30%	0.9	0.83	0.86
IEEE PETS 2001 Camera 2	70%	0.73	0.73	<b>0.73</b>
	50%	0.72	0.71	0.71
	30%	0.71	0.70	0.70
DARPA Neovision2 002	70%	0.73	0.97	<b>0.83</b>
	50%	0.72	0.96	0.82
	30%	0.72	0.94	0.82
DARPA Neovision2 012	70%	0.96	0.91	<b>0.93</b>
	50%	0.96	0.90	<b>0.93</b>
	30%	0.92	0.89	0.90

$$F - measure = \frac{2 \times Precision \times Recall}{Precision + Recall} \quad (5)$$

$$\text{where, } Precision = \frac{\text{Total no. of correct classification}}{\text{Total no. of classification}} \text{ and} \quad (6)$$

$$Recall = \frac{\text{Total no. of correct classification}}{\text{Total no. of actual classification}} \quad (7)$$

The results in Table 1 indicate that the proposed method satisfactorily classifies the motion objects from video sequence into various classes. A highest F-measure of 93% and a lowest of 73% are achieved by the proposed method for the 70% of the samples in the training set.

Nevertheless, the accuracy achieved for 50% and 30% of the samples in the training set are comparatively similar.

#### **4. Conclusion**

In this paper, an interval valued type symbolic representation scheme for classification of motion objects into predefined classes such as human, group of people, two wheeler, small vehicle or big vehicle is proposed. The seven invariant Hu moments features extracted from the motion object blob are symbolically represented for classification. The symbolic similarity measure is used for mapping the similarity of the interval valued feature value with the crisp feature value. Further, a simple nearest neighbor classifier is applied to classify the motion objects. Experiments on the benchmark IEEE PETS and DARPA Neovision2 datasets have been conducted and the accuracy has been established using F-measure accuracy metric for showing the efficacy of the proposed method. The results obtained are satisfactory.

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## **A Petri Net Model of Internal Organs Including Triple Energizer**

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**Abstract.** In traditional Chinese medicine, internal organs imply five viscera and six bowels. Five viscera mean Liver, Heart, Spleen, Lung, Kidney, and six bowels mean Gallbladder, Small Intestine, Stomach, Large Intestine, Urinary Bladder and Triple Energizer. In this study, we deal with the construction of Petri net model of internal organs based on traditional Chinese medicine. At first, we introduce our previous studies on using Petri net to construct a model of internal organs based on the relationship of mutual generation and mutual restriction between five viscera, i.e., five-elements theory. Then we describe how to construct a simulation model in order to investigate the interaction among the internal organs by using our Petri net model. Since our previous model does not include triple energizer, we investigate the relationship between triple energizer and the other internal organs to construct a new model including all the organs. Doing computational experiment under the assumption that Lung and Stomach are in weak states and comparing the experimental results, we show the effects of Triple Energizer and the usefulness of our new model.

**Keywords:** traditional Chinese medicine, five-elements theory, five viscera and six bowels, modeling, Petri net

### **1. Introduction**

Traditional Chinese medicine or oriental medicine has been widely applied in treating disease in China as well as in various Asian countries since ancient times. This is because of its less secondary effect and possible curing for ahead sick and incurable disease. Especially acupuncture and moxibustion therapy that stimulates acupuncture points in meridian system to treat disease has spread rapidly since the times when acupuncture and moxibustion therapy were admitted by WHO in 1989 and 361 acupuncture points were standardized by WHO in 2006. However mechanism of the meridian system is still not scientifically elucidated and many of related researchers and treatments have been made empirically and clinically. Therefore it is required to develop new knowledge to elucidate acupuncture and moxibustion treatment [1].

In traditional Chinese medicine, internal organs include five viscera and six bowels. Five viscera mean Liver, Heart, Spleen, Lung and Kidney, and six bowels mean Gallbladder, Small Intestine, Stomach, Large Intestine, Urinary Bladder and Triple Energizer. Five viscera and six bowels imply the systematic functions of the human body rather than internal organs of human anatomy. Five viscera and six bowels are closely related each other and have the correspondence relationship between Liver and Gallbladder, Heart and Small Intestine, Spleen and Stomach, Lung and Large Intestine, Kidney and Urinary Bladder, respectively. Once one becomes sick, the other has a high possibility of abnormalities. Such relationship is expressed in the five-elements theory of traditional Chinese medicine [2]. In Chinese medicine, the human body is also thought of a complex and interconnected system and consists of the meridian system that connects the skin to inner organs from head to foot. The elements of meridians are considered as the acupuncture points of the body. Stimulating acupuncture points on the body, various diseases can be treated and prevented [2].

Recently, five viscera of traditional Chinese medicine have been studied through modeling and quantitatively analyzing [3]. Fusing five-elements theory and fuzzy system theory, Sun et al. have proposed a fuzzy model (called Sun's model hereafter) of five viscera by focusing on the physiological equilibrium states of Liver, Heart, Spleen, Lung and Kidney [4]. Based on the evolution law of five viscera, Guo et al. have proposed a quantitative measurement model in order to realize five-elements theory [5]. Nevertheless, these models have a common problem that they are difficult to be used for simulating the behavior of five viscera as well as six bowels. On the other hand, Petri net is a modeling and analyzing tool of systems and can represent and analyze the static structure and dynamic behavior of a system. There have been many success stories on modeling biological systems and elucidating the mechanisms by Petri nets. On modeling and simulation of meridian system using Petri net [6], P.A. Heng et al. have presented an intelligent virtual environment for Chinese acupuncture learning and training using state-of-the-art virtual reality technology in order to develop a comprehensive virtual human model for studying Chinese medicine [7]; J. Pan and M. Zhou have modeled and analyzed meridian system by adopting Petri net methods [8]. However, these studies deal with the meridian system only, without taking into account of the internal organs, five viscera and six bowels. Till now, we have studied how to use Petri net to construct a model of internal organs with the meridian system as well as its simulation model based on five-elements theory [9, 10]. In these studies, Triple Energizer included in six bowels has not been taken into account yet, and hence a model including all internal organs is expected.

In this paper, we focus on modeling internal organs including Triple Energizer by using discrete Petri nets. Section 2 introduces five-elements theory in traditional Chinese medicine and gives basic knowledge of Petri nets. Section 3 introduces a model of internal organs without Triple Energizer. Section 4 describes construction of simulation model, proposes a new model of internal organs including Triple Energizer and further investigates the effects of Triple Energizer through computational experiment by using CPN Tools [11].

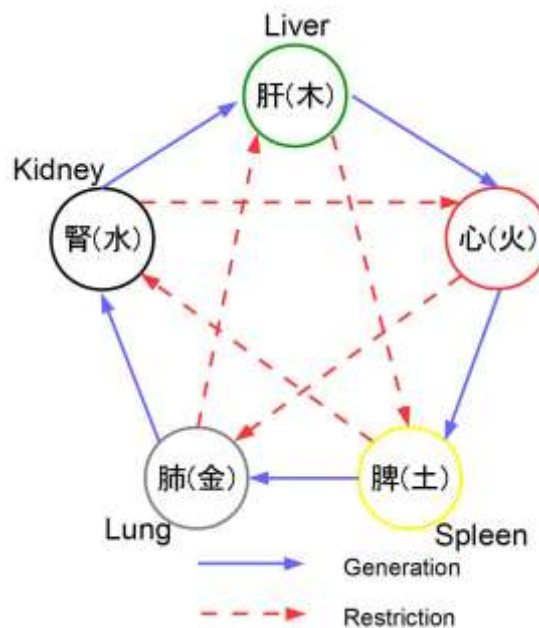
## 2. Five-Elements Theory and Petri Nets

### 2.1 Five-Elements Theory

According to ancient Chinese five-elements theory, the five elements, wood, fire, earth, metal and water are indispensable to the daily life of mankind. And in the five-elements theory of traditional Chinese medicine, five viscera, Liver, Heart, Spleen, Lung and Kidney,

are mapped to the five elements respectively. Liver flows Qi through over the body free of all care, as a tree getting taller; Heart warms the body as fire; Spleen produces nutrients, as soil that produces all things; Lung takes down Qi and Bodily Fluid, as astringent action of the metal; Kidney pools Mind and adjusts the moisture of the body, as water that flows to the low place from on high [2].

In five-elements theory, there are generation and restriction relationships between five viscera. Generation is that of mother-to-child relationship to give birth to the other party and is circulating in the order of wood  $\rightarrow$  fire  $\rightarrow$  earth  $\rightarrow$  metal  $\rightarrow$  water [2]. The restriction is to suppress the other party in the order of wood  $\rightarrow$  earth  $\rightarrow$  water  $\rightarrow$  fire  $\rightarrow$  metal [2]. In traditional Chinese medicine, health is maintained if generation and restriction relationships are balanced, and hence cause of the disease and methods of treatment can be investigated from the interrelationship of five viscera. Fig.1 shows the generation and restriction relationships.



**Fig. 1.** Generation and restriction relationships between five viscera.

In addition, five viscera and six bowels have relations that interact with each other. That is, Liver and Gallbladder, Heart and Small Intestine, Spleen and Stomach, Lung and Large Intestine, and Kidney and Urinary Bladder interact with each other, respectively. Triple Energizer consists of Upper Energizer, Middle Energizer and Lower Energizer, which are the paths for Qi and Bodily Fluid to pass.

## 2.2 Petri Nets and Colored Petri Nets

A Petri net is one of several mathematical modeling languages for the description of concurrent systems [6][12]. A Petri net is a weighted directed bipartite graph and consists of two types of nodes, transitions (i.e. events that may occur, signified by bars) and places (i.e. conditions, signified by circles). Places may contain a number of marks called tokens. Any token distribution over the places will represent a configuration of the net called a marking. The directed arcs with weights describe which places are pre- and/or post-conditions for which transitions (signified by arrows). If all the input places (preconditions) of a transition possess enough tokens, equal to or more than the weights respectively, then the transition can

fire to move the tokens to its output places (post-conditions). A Petri net is expressed by a 5-tuple  $PN = (P, T, A, W, M_0)$ . Here,  $P = \{p_1, p_2, \dots, p_{|P|}\}$  is a set of places,  $T = \{t_1, t_2, \dots, t_{|T|}\}$  is a set of transitions,  $A \subseteq (P \times T) \cup (T \times P)$  is a set of arcs,  $W$  is weight function  $A \mapsto \{1, 2, \dots\}$  and  $M_0$  is initial marking  $P \mapsto \{0, 1, 2, \dots\}$ . Fig.2 shows a Petri net with  $P = \{p_1, p_2, p_3, p_4\}$ ,  $T = \{t_1, t_2, t_3\}$  and  $M_0 = (3, 2, 1, 1)$ , in which  $t_1$  and  $t_3$  are fireable and  $t_2$  is not. After firing  $t_1$ , the marking becomes  $M = (0, 3, 2, 2)$ .

Colored Petri nets (CPN) is extended from Petri nets by adding colors to tokens and is a discrete event modeling language combining the capabilities of Petri nets with the capabilities of a high-level programming language. It allows tokens to have a data value attached to them. This attached data value is called token color. A colored Petri net is a tuple  $CPN = (P, T, A, \Sigma, C, N, E, G, I)$  [13], where,  $P, T$  and  $A$  are the same as Petri net,  $\Sigma$  is a set of color sets and contains all possible colors, operations and functions.  $C$  is a color function and maps places into colors.  $N$  is a node function and maps  $A$  into  $(P \times T) \cup (T \times P)$ .  $E$  is an arc expression function and maps each arc into the expression.  $G$  is a guard function and maps each transition into guard expression.  $I$  is an initialization function and maps each place into an initialization expression.

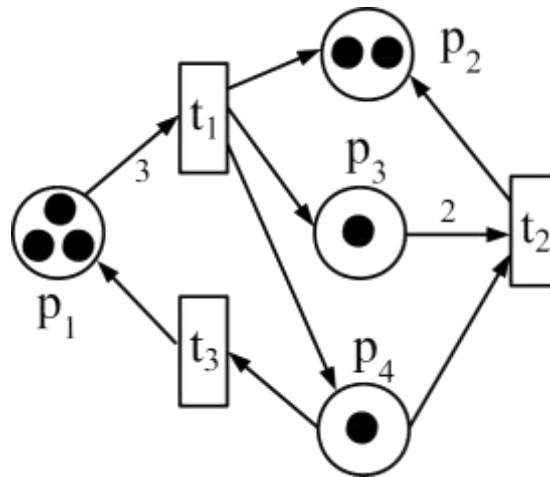


Fig. 2. An example Petri net.

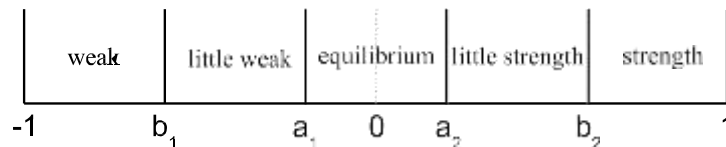


Fig. 3. Five viscera's state.

### 3. Modeling Method of Internal Organs by Petri Net

#### 3.1 A Control Model of Five Viscera

In Sun's model [4], physiological equilibrium states are quantitatively defined in a domain  $(-1, 1)$  individually for Liver, Heart, Spleen, Lung and Kidney, and a fuzzy model had been proposed based on the five-elements theory. The domain is divided into  $(-1, b_1)$ ,  $[b_1, a_1)$ ,  $[a_1, a_2]$ ,  $(a_2, b_2]$ ,  $(b_2, 1)$  as shown in Fig.3, which respectively express five states, weak, little weak, equilibrium, little strength, strength. These five states respectively represent dysfunction

and no power of generation  $((-1, b_1))$ , delicate health and weak power of generation  $([b_1, a_1))$ , health and stable state  $([a_1, a_2])$ , Excess and disease state with power of restriction  $((a_2, b_2])$ , and severe state of excess  $(b_2, 1)$ .

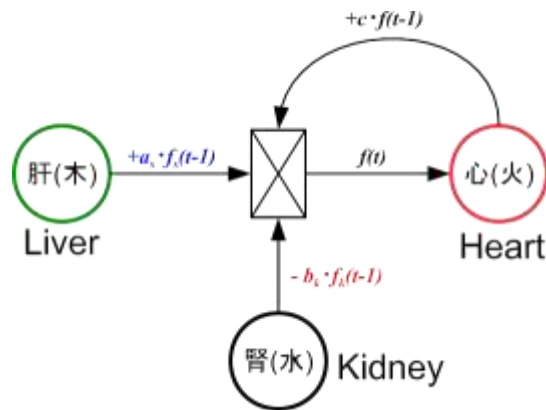
Among five viscera, there are generation and restriction relationships. In the case of Heart, it is generated by Liver but restricted by Kidney, which is shown in Fig.4. Meanwhile, the liver may lose its energy itself. Therefore, the state of Liver at time  $t$ ,  $f(t)$ , is expressed by the following equation that is modified from Sun's model [4]:

$$f(t) = a_s \cdot f_s(t-1) - b_k \cdot f_k(t-1) + c \cdot f(t-1) \quad (1)$$

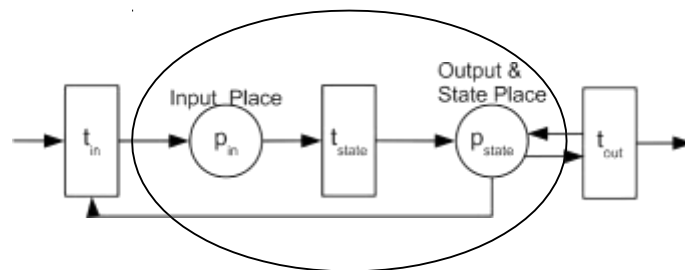
where,  $t$  is the time,  $a_s$ ,  $b_k$ ,  $c$  are non-negative parameters,  $a_s \cdot f_s(t-1)$  represents generation affection ( $f_s$  is the state of Liver) and  $b_k \cdot f_k(t-1)$  represents restriction affection ( $f_k$  is the state of Kidney).

### 3.2 Modeling Internal Organs

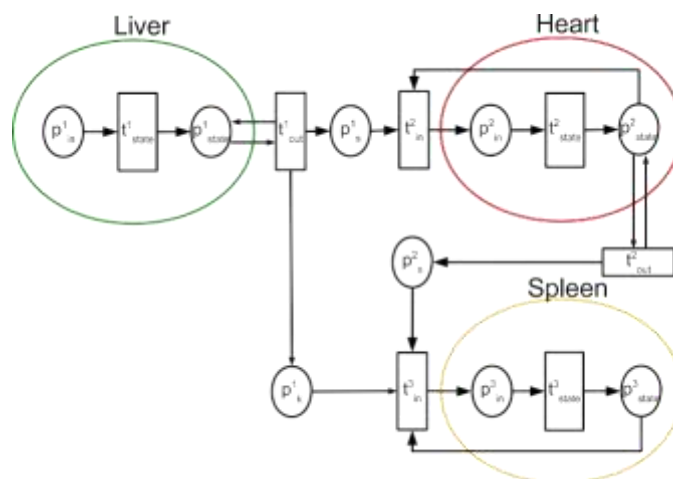
Based on Sun's model, a Petri net model of five viscera can be obtained. Fig.5 shows a model for a single viscus. Places,  $pin$  and  $pstate$ , are called input place and state place, and the token in state place is called state token whose value expresses the state of the viscus.  $t_{in}$  is called input transition that works to calculate the state value of Eq. (1).  $t_{state}$  is called state transition and works to generate a state of the viscus. The token with calculated state value



**Fig. 4.** Generation and restriction relationship.



**Fig. 5.** A Petri net model for a single viscus.

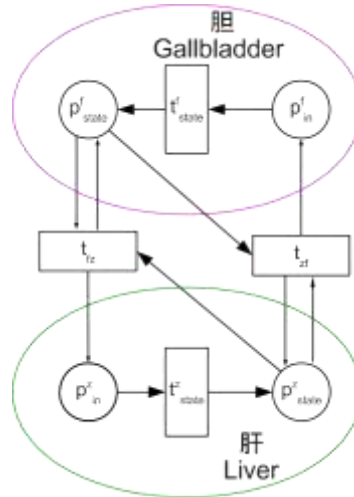


**Fig. 6.** A model including generation and restriction.

passes through  $p_{in}$  and  $t_{state}$  and then arrive at  $p_{state}$ .  $t_{out}$  is called output transition and

works to generate and restrict other viscera.

Fig.6 shows a Petri net model including the relationship of generation and restriction between viscera. This model is comprised of three single viscus models, the models of Liver, Heart and Spleen, which are connected by places  $p_s^1$ ,  $p_k^1$  and  $p_s^2$ . Places  $p_s^1$  and  $p_k^1$  express



**Fig. 7.** A Petri net mode of liver and gallbladder.

liver's generation and restriction affection to Heart and Spleen, respectively, and these two places are respectively called a generation-output place and restriction-output place of Liver. Tokens in generation-output and restriction-output places are respectively called generation token and restriction token. Similarly,  $p_s^2$  is the generation-output place of Heart. Since Liver generates Heart and restricts Spleen, state token of Liver flows through output transition  $t_{out}^1$  to generation-output place  $p_s^1$  (that is also an input place of heart model) and to restriction-output place  $p_k^1$  (that is also an input place of spleen model). In the same way, state token of Heart flows to generation-output place  $p_s^2$  that is an input place of spleen model.

Five viscera and six bowels are in the relationship of the front and back, such as Liver and Gallbladder, Heart and Small Intestine, Spleen and Stomach, Lung and Large Intestine, and Kidney and Urinary Bladder. Each of these pairs interacts with each other to maintain life. Such a pair, for example Liver and Gallbladder, is modeled by Petri net as shown in Fig.7. This model is made by adding transitions  $t_{zf}$  and  $t_{zc}$  and connecting them to the single model of liver and gallbladder.  $t_{zf}$  and  $t_{zc}$  represent the affections from Liver to Gallbladder and from Gallbladder to Liver, respectively.

Synthesizing the models we have made till now, we can complete a model of internal organs. The process is summarized as follows: (1) Make a single model for each of five viscera as Fig.5; (2) Connect these single models according to generation and restriction relationship between five viscera as Fig.6; (3) Add to the model of each viscus by the model of its pair partner of six bowels as Fig.7. Then a model of internal organs except triple energizer is obtained as shown in Fig.8 [9].

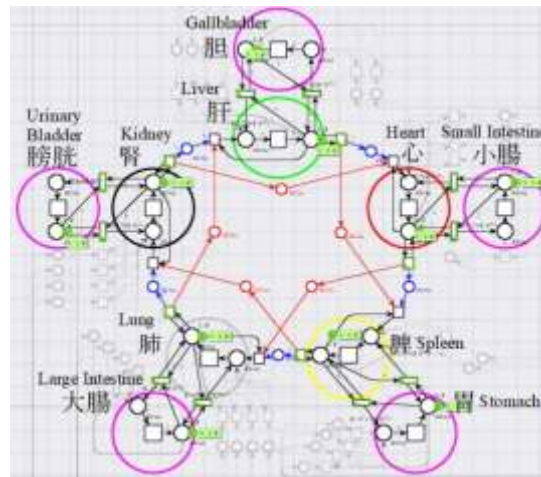


## 4. A Full Model of Internal Organs and Simulation Result

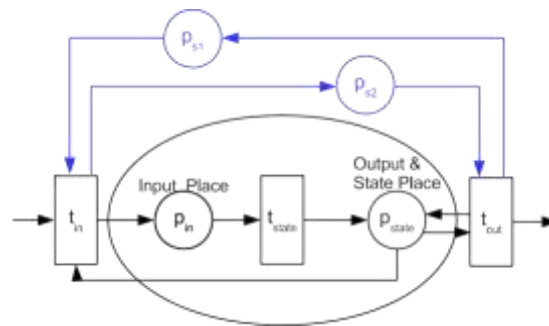
### 4.1 Construction of Simulation Model

In a Petri net, a marking is changed to another one by firing a firable transition. In simulating a Petri net model by using CPN Tools [11], there may exist plural firable transitions and it is nondeterministic that which one will be selected to fire. However, in traditional Chinese medicine, human life activities, the activities of each organ and physiological activities such as circulation and metabolism of blood are all working based on certain rhythm; and it is fundamental that work of all the internal organs should be balanced. Therefore, it is necessary to construct such a simulation Petri net model that the activities of internal organs could be simulated in a good balance.

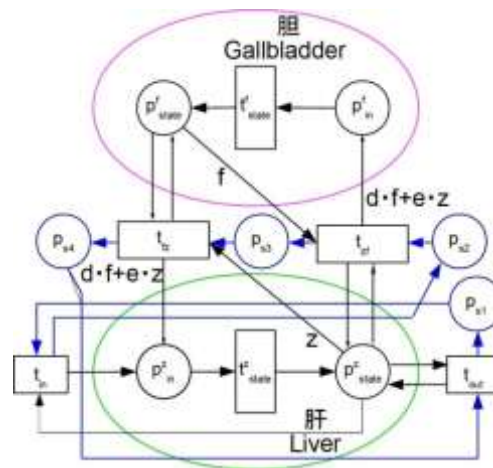
To let all the transitions fire in turn, we do the following operations. (1) For each viscus, we add two places  $p_{s1}$  and  $p_{s2}$  between the input and output transitions,  $t_{in}$  and  $t_{out}$ , as shown in Fig.9. Thus a simulation model of five viscera can be obtained and all the transitions must fire in turn. (2) To let a pair of viscus and bowel fire alternately, we construct a model of a viscus and its related bowel as shown in Fig.10. In this model, we add a bowel to its viscus (Fig. 9) and further change  $p_{s2}$  of Fig.9 to  $p_{s2}$ ,  $p_{s3}$  and  $p_{s4}$ . Thus the transitions can fire in the turn of  $t_{in} \rightarrow t_{state}^z \rightarrow t_{zf} \rightarrow t_{state}^f \rightarrow t_{fz} \rightarrow t_{out}$ . In this way, a simulation model of internal organs except triple energizer is obtained as shown in Fig.11 [10].



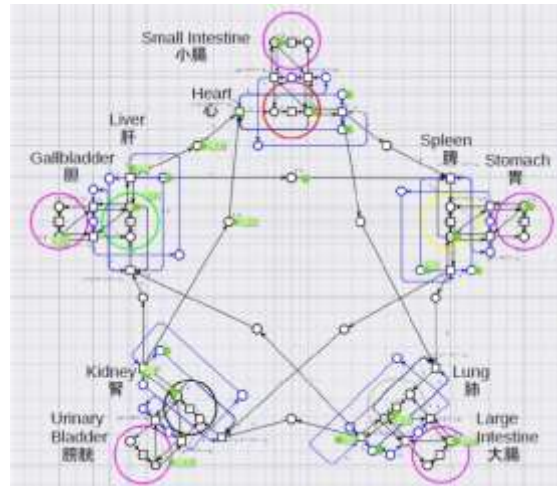
**Fig. 8.** A Petri net model of internal organs except triple energizer.



**Fig. 9.** Adding  $p_{s1}$  and  $p_{s2}$  to a single viscous.



**Fig. 10.** Adding a bowel to its corresponding viscera.



**Fig. 11.** A simulation model without energizer.

**Table 1.** The relationship between triple energizer and five viscera.

Five Viscera	Liver (肝臟)	Heart (心臟)	Spleen (脾臟)	Lung (肺臟)	Kidney (腎臟)
Upper Energizer (上焦)		*		*	
Middle Energizer (中焦)	*		*		
Lower Energizer (下焦)					*

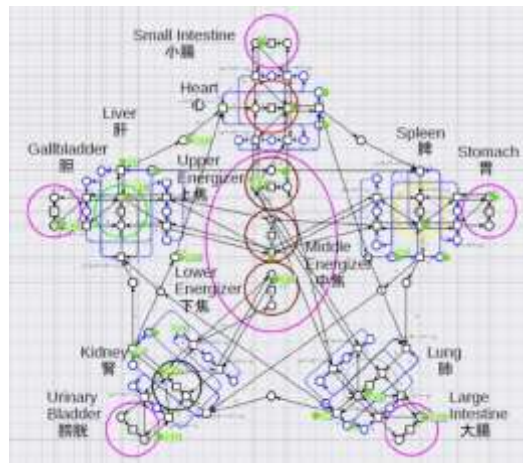
## 4.2 A Model of Internal Organs Including Triple Energizer

Triple energizer is considered as one of six bowels in traditional Chinese medicine. Different from other bowels, it has no shape but works as the lymphatic vessels through the whole human body and the paths for Qi and Bodily Fluid to pass [14, 15]. Triple Energizer consists of Upper Energizer, Middle Energizer and Lower Energizer, which respectively refer to the three parts of human body, from the diaphragm up to the upper limbs and head, from the diaphragm to the belly button and from the belly button to the foot [16].

Like other bowels, Triple Energizer has the relationship of the front and back to five viscera. Upper and middle energizers individually have two viscera as their opposite, but Lower Energizer has only one viscus as its opposite. Concretely, Upper Energizer, Middle Energizer and Lower Energizer are respectively related to Lung and Heart, Spleen and Stomach, and Kidney as shown in Table 1, in which notion “\*” shows the efficacious relation. For Upper Energizer and Middle Energizer, we need only to connect each energizer to its related two viscera in the same way as shown in Fig.10. Thus, we construct an internal model (simulation model) including Triple Energizer as shown in Fig.12 by adding Triple Energizer to the model of Fig.11.

## 4.3 The Effects of Triple Energizer

To clarify the functional behavior of Triple Energizer and the behavioral difference between our previous model and the new one, we have done computational experiment under the assumption that Lung and Stomach are in both weak states. The parameters are set as follows:



**Fig. 12.** An internal model including triple energizer.

- (1) Data type for each place is defined by REAL;
- (2) Value of state token of each organ is defined in domain (0.5, 5.5), which means that (0.5, 1.5), [1.5, 2.5], [2.5, 3.5], (3.5, 4.5], (4.5, 5.5) respectively five states, weak, little weak, equilibrium, little strength, strength;
- (3) The parameters  $a_s$ ,  $b_k$ ,  $c$  in equation  $f(t) = a_s \cdot f_s(t-1) - b_k \cdot f_k(t-1) + c \cdot f(t-1)$  are defined as  $a_s = 0.15$ ,  $b_k = 0.05$ ,  $c = 0.90$ ;
- (4) For each pair of five viscera and six bowels (e.g. Liver and Gallbladder as shown in Fig.10), set expression  $z$  for arc  $(p_f^{state}, t_{zf})$ ,  $f$  for  $(p_f^{state}, t_{zf})$ ,  $d \cdot f + e \cdot z$  for  $(t_{zf}, p_{in}^f)$  and  $d \cdot z + e \cdot f$  for  $(t_{zf}, p_{in}^z)$ , where  $d$  and  $e$  are defined as  $d = 0.90$ ,  $e = 0.10$ ; and  $z$  and  $f$  respectively indicate states of Liver and Gallbladder.

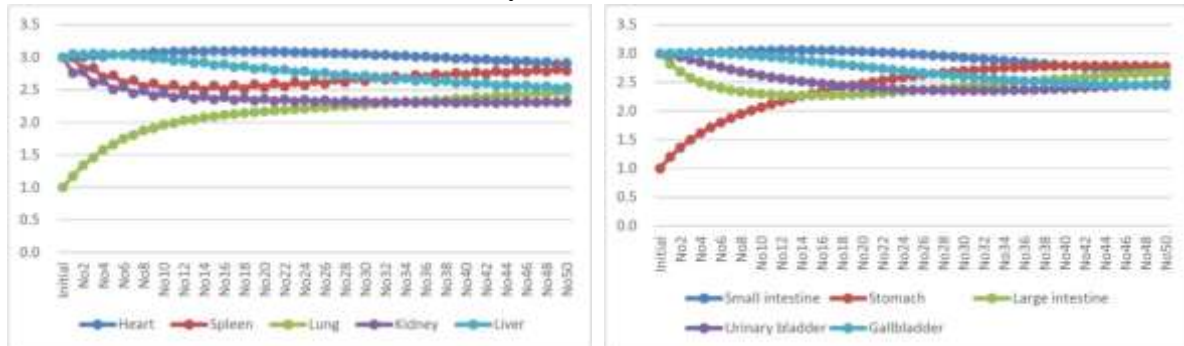
The results are shown in Fig.13 and Fig.14 respectively for the models of Fig.11 and Fig.12. We can find that, (1) in both of the figures, Lung and Stomach gradually recover their states from 1 to about 2.5 and all the other viscera and bowels also reach their states around 2.5 due to the generation and restriction relationships among the five viscera; (2) in Fig.13, a part of viscera and bowels fluctuate relatively fiercely and however in Fig.12 all the viscera and bowels gently change their states to around 2.5, without fierce fluctuation. These means Triple Energizer can lose intense changes of the states of the viscera and bowels, i.e., Triple Energizer may probably prevent rapid changes of our human body.

## 5. Conclusions

We have proposed a new internal organ model based on the five-elements theory of traditional Chinese medicine. We firstly constructed a new internal organ model by investigating relationships between Triple Energizer and five viscera and adding Triple Energizer to our previous model without Triple Energizer. Doing a computational experiment by using CPN Tools under the assumption that Lung and Stomach are in weak states and comparing experimental results of our previous model and the new one, we showed effects of Triple Energizer and usefulness of our new internal organ model.

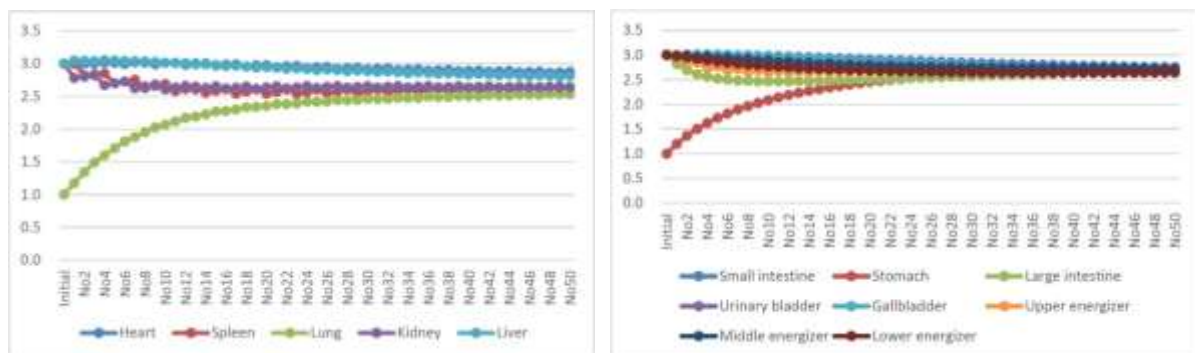
It should be pointed out that this work does not intend to be a scientific contribution to medical science in the sense as it is usually understood. As the future works, we are to (1)

design a Petri net model including internal organs and 12 principal meridians; (2) decide parameters for all the transitions and places, as well as for tokens and arcs on the basis of the data of acupuncture treatment site; (3) do simulation to verify the validity of our proposed model and the parameters, in order to improve our model; (4) develop a method to construct a Petri net model for the whole human body.



(1) State change of five viscera

(2) State change of five bowels

**Fig. 13.** Simulation results for the previous model shown in Fig.11.

(1) State change of five viscera

(2) State change of six bowels

**Fig. 14.** Simulation results for the new model shown in Fig.12.

## Acknowledgement

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**Prevalence and Correlates of Non-Suicidal Self-Harm, Suicidal Ideation and Suicidal Behaviour  
in a Sample of Kenyan University Students**

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**Running Head: Suicide among Kenyan University Students**

**ABSTRACT**

**Background:** Suicide stands as a disconcerting mental illness. Modern psychiatry increasingly recognizes suicide as an independent illness. According to the DSM-5, suicide encompasses a breadth of disorders ranging from the non-suicidal self-harm to suicidal ideation and suicidal behavior. Contrary to the past, these conditions are increasing in Africa, including in Kenya. University students have been cited as a vulnerable population

**Purpose:** This study aimed at elucidating the prevalence of non-suicidal self-harm, suicidal ideation and suicidal behavior among students attending a Kenyan university, and related socio-demographic determinants.

**Methodology:** A cross-sectional descriptive survey on a sample of 246 students was implemented. Three validated suicide scales (Suicidal Behaviour Questionnaire, Inventory of Statements About Self-Injury Behaviours and Functions) and a demographic questionnaire were used to collect data.

**Results:** The rates of some non-suicidal self-harm behaviors were notable such as interfering with wounds (15.5%), banging self (12.9%), pinching (12.9%), pulling hair (12.9%), and severe scratching (11.2%). The rate of suicidal ideation and suicidal behavior was 9.4% and 3.2% respectively. The threat of suicide was evidenced with 2.9% having contemplated committing suicide in the past and the future. Further, 14.6% were categorized under high suicide risk implying a significant risk given a cut-off of  $\geq 7$  for undergraduate students. Regression analysis showed that bisexuals had a 3.92 higher odds of suicidal behaviour (CI: 1.09 – 14.15,  $p=0.037$ ) as opposed to heterosexuals. Further, lifetime drug use was a predictor of suicidal behavior ( $p=0.047$ ) with those using drugs having a 4.16 higher odds of exhibiting suicidal behaviour, compared to those who had never used drugs.

**Conclusion:** These findings suggest that a significant proportion of students reported suicidal ideation and behaviors that are closely related to usage of drugs and sexual activity. The findings have specific implications for detecting suicide among vulnerable populations within university precincts.

**Keywords:** Suicidal ideation, suicidal behavior, non-suicidal self-harm, suicidality, university, Kenya



## Introduction

The escalation of suicide, suicide attempts, and the increasing intricacy of its correlates, including the contagion effect, is a public health concern over the recent past [1]. Suicide is classified as one of the top three causes of mortality among young people around the globe. Contrary to the perception that exists that mental problems are an issue for youth in western countries, studies show that they are also prevalent in other parts of the globe [2]. Indeed, especially for young people, that there has long existed an epidemic of mental illness around the world [3]. Whereas there are different manifestations of mental illness – ranging from alcohol and substance used disorders, depression, bipolar disorder, psychosis and post-traumatic stress disorder (PTSD), among others. None, however, is arguably as chilling to the psyche as suicide [4].

The World Health Organization's data shows that one million people die from this mental illness; a global death rate of 16 per 100,000, which translates to one suicide attempt every 3 seconds [5]. The prevalence is expected to rise to 1.53 million by 2020 [6]. It is estimated that for each "successful" suicide, there are between 10 and 20 unsuccessful attempts and a further twenty-five and fifty cases of non-suicidal self-harm – indicating the global burden of suicide and self-harm to be somewhere between 25 and 50 million individuals [16, 17].

Cases of suicide and suicidality are on the rise on the African continent and in Kenya as a country. A previous study done in South Africa, among children and adolescents, highlighted a suicide attempt rate of 3.2%, those who were planning suicide were 5.8% and those who reported suicide ideation were 7.2% [8] – indicating that this phenomenon may not be as uncommon as previously thought. Studies show that suicide is indeed emerging as a major public health concern in Africa. However, the lack of routine data means that it is hard to document the extent of the problem [9].

Among university students, certain suicide-related behaviors are common and have been well documented in Western countries. Most notably, non-suicidal self-injury (NSSI), also known as self-injury or self-mutilation, has been severally demonstrated as a common practice among students in institutions of higher learning around the globe [13, 20, 21]. Further, recent studies show that there exists a link between non-suicidal self-harm and suicidality in future [21, 22], though the mechanism is not well understood [4]. The possibility that a suicide epidemic may be quietly sweeping through university students on the African continent cannot be ignored.

This study, thus, sought to elucidate the status of self-harm, suicidal ideation, and behavior in a sample of African university students and by so doing provide baseline data for future intervention. In specific, the study sought to determine the prevalence of non-suicidal self-harm, the prevalence of suicidal behavior and correlated of non-suicidal self-harm, suicidal ideation, and suicidal behavior among students enrolled in a Kenyan university.

This study will assist the universities to gain clarity on the problem of suicidal behavior and ideation that may be present among students. This will ensure that they understand the extent of the problem and can institute mitigation measures if need be. For the students attending Kenyan universities, this study may be the first step towards highlighting some of the mental health issues they face and form a starting point for addressing the issues. To those in academia and research, it will shed light on an oft-ignored mental health problem and help to jump start the conversation on suicide in Kenya and the African continent as a whole.

## Methodology

### *Participants*

In a campus population consisting of 990 students, a representative stratified random sample based on gender and residence was retrieved, with a confidence interval (CI) of 95% and a 5% margin error from two major groups of students: on-campus and off-campus. In this process, and through the application of Yates' finite population correction, 246 students took

part in the study. Respondents were stratified by residence, that is, either on-campus or off-campus; and sex.

### ***Instruments***

The demographic section was followed by dichotomous questions to assess lifetime and previous past behaviours relating to drugs, relationship, and sexual activity. Respondents could only select one of the responses to every question. This section was followed by four items extracted from the Suicide Behaviours Questionnaire-Revised (SBQ-R) which is validated for use among university students [13]. The last section of the self-administered questionnaire contained questions adapted from two sections of the Inventory of Statements about Self-Injury (ISAS) [14]. These sections were: Behaviours and Functions.

### ***Procedures***

After necessary ethical approval was granted by the University of Eastern Africa, Baraton, Institutional Research and Ethics Committee (UEAB-IREC), the participants were requested to fill questionnaires through either Google Forms or the conventional print questionnaires in secluded rooms for confidentiality. All participants were required to have read informed consent and advice forms and sign their willingness to participate.

### ***Data Analysis***

Data analyses were done using IBM SPSS® version 23. A frequency distribution analysis was first done to establish basic descriptive statistics that allowed the initial approximation to the pattern of behavior of each variable included in the dataset. This also helped to assess the relative effectiveness and success of the data cleaning and consistency controls already executed. In the case of discrete variables, frequency tables with single or multiple cross-classification criteria provided a good description of the variables.

The prevalence of non-suicidal self-harm, suicidal ideation, and suicidal behavior was calculated. Also, the scores for each of the conditions was calculated based on the Likert scale responses. Spearman's rank-sum correlation coefficient was used for bivariate analysis of the socio-demographic factors predicting non-suicidal self-harm, suicidal ideation, and suicidal behavior respectively. To adjust for confounding, all independent variables that significantly correlate with the dependent variables (non-suicidal self-harm, suicidal ideation, and suicidal behavior) at bivariate analysis was considered together using logistic regression.

### ***Ethical Considerations***

All the ethical attentions were considered with the sole purpose of protecting the participants and their views. As mentioned to beforehand, ethical approval was safeguarded by the researchers. Before commencement of the questionnaire filling exercise, informed consent was read to participants, and every participant was required to demonstrate a willingness to participate. The ethical insinuations of participation, or non-participation, were elucidated on the introductory part of the questionnaire. Further, absolute anonymity was required, and no personal information that might be used for identification was requested. Instead, the participants were informed that they could get in touch with the principal investigator whenever they felt the need to do so for support.

## **Results**

### ***Demographics***

From the responses, 122 (51.3%) were male and 116 (48.7%) were female. The participants were from various nationality: American, Burundian, Congolese, Finnish, Ghanaian, Indian, among others but majorly from Kenya 117 (72.1%). The participants hailed from all schools including Business, Education, Health sciences, Humanities and Social sciences, Nursing, and Science and technology. Among the respondents were 140 (82.8%) heterosexual, 23 (13.6%) were bi-sexual and 6 (3.6%) were homosexual. While 38.0% reported that they were involved in a serious long-term relationship, 51.5% reported that they were sexually active. Approximately one-third (33.6%) reported that they had experienced bullying in high school.

Most, 208 (85.6%) were single, and the rest were either married (n=32, 13.2%) or divorced (n=3, 1.2%). Almost all of the respondents (96.1%) were Christians of various denominations including Seventh-day Adventists (70.1%), Protestants (13.7%) and Catholics (12.0%), among others. In terms of year of study, 12.8% were freshmen, 9.4% were sophomores, 47.2% were junior year students and 30.6% were senior year students. The mean age was  $23.25 \pm 5.25$ , and a majority of the students received an average allowance Ksh.  $6,403 \pm 556.26$  (US\$1 = Ksh102).

Respondents were queried on their substance use related behaviours in terms of lifetime use and past 30-day use. Lifetime use rates were 26.3%, 16.2% and 11.1% for alcohol, drugs and tobacco respectively. Past 30-day use rates stood at 9.8%, 10.0% and 9.9% for alcohol, drugs and tobacco respectively.

### ***The Prevalence of Non-Suicidal Self-Harm***

The prevalence of self-reported non-suicidal self-harm behavior was 47.3% (116/245) with some of the notable non-suicidal self-harm practices ranging from banging oneself (n=15, 12.9%) to severe scratching (n=13, 11.25). Other serious self-inflicted harm behaviors included pinching, pulling hair, cutting, and burning (Table 1).

### ***Suicidal Ideation and Suicidal Behaviour***

The prevalence of suicidal ideation was 9.4% with that of suicidal behavior at 3.2%. A majority responded that they had never had suicidal thoughts, but around 9% had harboured figments of suicide while 8.6% had made suicide plans at varying degree by reporting to have had thoughts such as “I have had a plan to kill myself at least once, but I did not try it” and “I have had a plan to kill myself at least once, and I really wanted to die” (Table 2).

Further, analysis of responses from the Suicide Behaviours Questionnaire-Revised (SBQ-R) showed that the mean suicide risk score was  $4.23 \pm 2.61$ . The suicide risk classification for the population was notably significant with 35 (14.6%) falling under the high suicide risk against cut-off of  $\geq 7$  for undergraduate students.

### ***Correlates of Non-Suicidal Self-Harm, Suicidal Ideation, and Suicidal Behavior***

At the bivariate level, predictor variables and the dependent variables – non suicidal self harm, suicidal ideation and suicidal behavior exhibited significant relationships. The residence of the participants correlated with non-suicidal self injury ( $p=0.014$ ) and the odds of on-campus students (students residing in designated halls of residence within campus) for non-suicidal self injury were higher than those of off-campus students 2.01 (1.15 – 3.53). Sexual orientation also correlated with non-suicidal self-injury at significant level ( $p=0.044$ ) and bi-sexuals had higher odds for non-suicidal self injury as opposed to heterosexual participants. Lifetime alcohol use ( $p<0.0001$ , OR 1.94 95% CI: 1.08 – 3.46), lifetime drug use ( $p<0.001$ , OR 3.99 95% CI: 1.85 – 8.63), romantic relationship ( $p<0.0001$ , OR 2.92 95%CI: 1.70 – 5.00), and lifetime bullying ( $p<0.0001$ , OR 2.06 95% CI: 1.19 – 3.57) were also predictor variables for non-suicidal self harm. Further, participants taking studies under the school of education had higher odds for suicidal ideation  $p=0.036$ , OR 4.56 95%CI: 1.10 – 18.86) as opposed to students in school of business. Variables predicting suicidal behavior at significant level included sexual orientation ( $p=0.003$ ) and marital status ( $p=0.029$ ) where the odds for bi-sexual participants for suicidal behavior over heterosexual participants were OR 22.83 95%CI: 2.95 – 176.81, the odds for divorced or separated participants over single participants were OR 16.83, 95%CI: 1.34 – 212.18, the odds of those using alcohol over those not using OR 6.14, 95%CI: 1.37 – 27.53, and those in relationship OR 12.27, 95%CI: 1.48 – 101.43 (Table 3).

Multivariate analysis showed that sexual orientation was a significant factor in explaining suicidal behaviour. Bisexuals had a 3.92 higher odds (CI: 1.09 – 14.15,  $p=0.037$ ) as opposed to heterosexuals. Further, lifetime drug use was a predictor of suicidal behavior with those using drugs having a 4.16

higher odds ( $p=0.047$ ) of exhibiting suicidal behaviour, compared to those who had never used drugs. None of the factors that were significantly associated with non-suicidal self-harm and suicidal ideation at the bivariate level, remained statistically significant at the multivariate level.

### Discussion

Suicidal ideation and behavior is an issue of public health concern especially given that prevalence in institutions of higher learning is high. The findings of this research depict that the prevalence of suicidal ideation is at 9.4% while the prevalence of suicidal behavior is 4.5%. Findings from other similar studies show the prevalence of suicidal ideation to be at even more worrisome levels. For instance, suicidal ideation in Austrian universities was found to be 35%, 26% for Turkish students, and 43% for Norwegian students [15]. The reason underlying the variation could include religiosity, which has been found to have strong connotations towards lower suicidal ideation and behavior [16]. In response to whether they have ever considered committing suicide in the past and whether they will ever commit suicide in the future, 2.9% of the participants were affirmative that they have ever wished they would die or would consider committing suicide. In this aspect, literature on the subject is relatively similar with rates for the same ranging from 0.3% among Austrian students to 8% among Norwegian students [27, 28].

Aside from extreme suicidal ideation and behavior, findings from this study established that there are different behaviors risky behaviors among college students. Notable behaviors emanating from the results of this study include banging oneself (12.9%) and severe scratching (11.3%). Similarly, other studies have reported burning and cutting oneself as habits that have been practiced among college students but without suicidal ideation [19]. Other forms of non-suicidal behaviors reported among university students include pinching, punching, ingesting harmful substances, interfering with wounds, and breaking bones [30, 31]. Both genders inflict pain on self and engage in such behavior and, as such, there is no consistent difference in the patterns [22].

The implications of the findings on non-suicidal injury among college students are that such behaviors are occurring among the young population than earlier assumptions. The significance of assessing precursors to suicidal ideation and behavior still stand. However, the importance of understanding non-suicidal self-injury activities is that it provides insights regarding coping mechanisms assumed by university students that do not necessarily end with suicidal ideations or suicide itself. Considering self-injury is a matter of concern with close connections with suicidal ideation and behavior, psychotherapeutic interventions including skill building approaches have been proposed to avert such behavior and assist at-risk population [23].

This study identified several correlates of suicidal ideation and behavior and narrowed down to two that were depicting significant correlation and odds. The two most important precursors, as indicated by the analysis, were sexual orientation – where lesbians and gays were more likely to have suicidal ideation and behaviors – and long-term use of drugs, including alcohol consumption. Some studies establish the same linkages elucidated in this study; that drugs invoke suicidal thinking among university students [24] [25]. On the other hand, suicidal ideation among lesbian, gay, bisexual and transgender college students, otherwise known as LGBT, has been assessed and their prevalence rates found to be high [26] majorly because attitudes towards them are usually negative [27].

While there were limitations encountered in this research endeavor including the fact that the inferences from this study are limited to self-reported information given by respondents that presents the aspect of overestimation and underestimation of variables, there were some opportunities to averting the limitation. Specifically, this study employed the use of validated questionnaires to mitigate this effect.

### **Conclusion**

In total, the implications of the findings of this study are that students in the university should be provided with psychiatric and counseling support and advice. From the findings, predictor variables that were thought to have a direct causal relation to non-suicidal self-injury, suicidal ideation, and suicidal behaviour were myriad but adjusted odds ratio analysis eventually showed significant relationship on few. Further research on the area of suicidal ideation and behavior should focus on LGBTs to provide more understanding of the dynamics they undergo.

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**TABLES****Table 3. The Prevalence of Non-Suicidal Self-Harm Behaviours**

Characteristic	Frequency	Percent (%)
Cutting	10	8.6
Banging or Hitting Self	15	12.9
Biting	7	6.0
Interfering with wound healing (e.g. picking scabs)	18	15.5
Carving	8	6.9
Sticking Self with Needles	7	6.0
Severe Scratching	13	11.2
Burning	10	8.6
Pinching	15	12.9
Swallowing Dangerous Substances	10	8.6
Rubbing Skin against Rough Surface	7	6.0
Pulling Hair	15	12.9

**Table 4. Frequency of Suicidal Ideation and Behaviour**

Response	Frequency (n)	Percent (%)
Never ( <b>Non-suicidal</b> )	195	79.9
It was just a brief passing thought ( <b>suicidal ideation</b> )	23	9.4
I have had a plan at least once to kill myself but I did not try it ( <b>suicide plan</b> )	12	4.9
I have had a plan at least once to kill myself and I really wanted to die ( <b>suicide plan</b> )	6	2.5
I have attempted to kill myself, but did not want to die ( <b>suicide attempt</b> )	5	2.0
I have attempted to kill myself, and really hoped to die ( <b>suicide attempt</b> )	3	1.2



**Table 5. Unadjusted Odds Ratios for Variables Predicting Non-Suicidal Self-Injury, Suicidal Ideation and Suicidal Behaviour in a Kenyan University**

Independent Variables	Category	Dependent Variable		
		Non-suicidal self-injury	Suicidal Ideation	Suicidal Behaviour
		<i>OR (95% CI)</i>	<i>OR (95% CI)</i>	<i>OR (95% CI)</i>
NSSI	Yes vs. No		1.01 (0.43 – 2.39)	8.16 (0.99 – 67.33)
Suicidal Ideation	Yes vs. No	1.01 (0.43 – 2.39)		0.00
Suicidal Behaviour	Yes vs. No	8.16 (0.99 – 67.33)	0.00	
Age	Yes vs. No	0.95 (0.90 – 1.00)	0.94 (0.85 – 1.05)	0.92 (0.76 – 1.13)
Gender	Male vs. Female	0.88 (0.53 – 1.46)	0.58 (0.24 – 1.40)	1.44 (0.24 – 8.77)
Academic School (1)	Education vs. Business	1.85 (0.70 – 4.89)	4.56 (1.10 – 18.86)*	3.10 (0.19 – 51.68)
Academic School (2)	Health Sciences vs. Business	1.54 (0.75 – 3.16)	2.58 (0.73 – 9.09)	5.00 (0.54 – 46.10)
Academic School (3)	Humanities vs. Business	0.68 (0.26 – 1.80)	0.62 (0.07 – 5.82)	2.60 (0.16 – 43.18)
Academic School (4)	Nursing vs. Business	2.46 (0.73 – 8.35)	0.00	0.00
Academic School (5)	Sci & Tech vs. Business	1.95 (0.84 – 4.50)	2.07 (0.48 – 8.84)	0.00
Residence	On-campus vs.	2.01 (1.15 – 3.53)*	0.46 (0.16 –	5.05 (1.00 – 25.67)

	Off-campus		1.32)	
Sexual Orientation (1)	Lesbian/Gay vs. Heterosexual	6.86 (0.78 – 60.31)	1.55 (0.17 – 14.12)	22.83 (2.95 – 176.81) **
Sexual Orientation (2)	Bi-sexual vs. Heterosexual	2.57 (1.03 – 6.47) *	0.74 (0.16 – 3.45)	0.00
Marital Status (1)	Married vs. Single	0.99 (0.47 – 2.09)	0.27 (0.04 – 2.10)	1.09 (0.13 – 9.33)
Marital Status (2)	Divorced vs. Single	2.25 (0.20 – 25.14)	0.00	16.83 (1.34 – 212.18) *
Pocket Money		1.00	1.00	1.00
School Year (1)	Sophomore vs. Freshman	2.11 (0.59 – 7.60)	0.42 (0.04 – 4.40)	1.00
School Year (2)	Junior vs. Freshman	1.67 (0.64 – 4.34)	0.60 (0.14 – 2.52)	1.01×10 <sup>8</sup>
School Year (3)	Senior vs. Freshman	1.45 (0.53 – 3.99)	0.67 (0.15 – 3.06)	6.10×10 <sup>7</sup>
Lifetime Alcohol Use	Yes vs. No	1.94 (1.08 – 3.46) *	1.93 (0.79 – 4.70)	1.71 (0.40 – 7.38)
Past 30 days Alcohol Use	Yes vs. No	2.97 (1.18 – 7.44) *	0.86 (0.19 – 3.92)	6.14 (1.37 – 27.53) *
Lifetime Drug Use	Yes vs. No	3.99 (1.85 – 8.63) **	0.80 (0.23 – 2.86)	3.28 (0.75 – 14.35)
Past 30 days Drug Use	Yes vs. No	1.97 (0.83 – 4.70)	0.89 (0.20 – 4.07)	3.18 (0.61 – 16.73)
Lifetime Tobacco Use	Yes vs. No	2.94 (1.23 – 7.00) *	1.23 (0.34 – 4.45)	2.81 (0.54 – 14.70)

Past 30 days Tobacco Use	Yes vs. No	3.70 (1.42 – 9.69) **	0.86 (0.19 – 3.90)	3.23 (0.61 – 16.96)
In Romantic Relationship	Yes vs. No	2.92 (1.70 – 5.00) **	1.29 (0.54 – 3.06)	12.27 (1.48 – 101.43) *
Sexually Active	Yes vs. No	2.72 (1.60 – 4.61) **	0.68 (0.28 – 1.69)	2.92 (0.58 – 14.78)
Ever been Bullied	Yes vs. No	2.06 (1.19 – 3.57) *	2.36 (0.99 – 5.62)	0.65 (0.13 – 3.29)
No. of Siblings	Diploma vs. Degree	0.99 (0.88 – 1.11)	0.93 (0.76 – 1.14)	0.88 (0.60 – 1.30)

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**Table 6. Adjusted Odds Ratios for Variables Predicting Non-Suicidal Self-Injury, Suicidal Ideation and Suicidal Behaviour**

Independent Variables	Category	Dependent Variable		
		NSSI	Suicidal Ideation	Suicidal Behaviour
		<i>AOR (95% CI)</i>	<i>AOR (95% CI)</i>	<i>AOR (95% CI)</i>
Residence	On-campus vs. Off-campus	1.04 (0.44 – 2.43)		
Sexual Orientation (1)	Lesbian/Gay vs. Heterosexual	5.08 (0.34 – 75.41)		4.34 (0.34 – 54.99)
Sexual Orientation (2)	Bi-sexual vs. Heterosexual	5.28 (0.93 – 30.13)		3.92 (1.09 – 14.15) *
Lifetime Alcohol Use	Yes vs. No	0.85 (0.31 – 2.37)		0.68 (0.25 – 1.83)
Past 30 days Alcohol Use	Yes vs. No	0.85 (0.15 – 4.93)		0.87 (0.16 – 4.66)
Lifetime Drug Use	Yes vs. No	3.32 (0.78 – 14.11)		4.16 (1.02 – 16.97) *
Lifetime Tobacco Use	Yes vs. No	0.25 (0.03 – 2.11)		0.26 (0.04 – 1.57)
Past 30 days Tobacco Use	Yes vs. No	1.47 (0.28 – 7.82)		1.44 (0.30 – 6.91)
In Romantic Relationship	Yes vs. No	1.69 (0.74 – 3.82)		1.71 (0.80 – 3.66)
Sexually Active	Yes vs. No	1.92 (0.85 – 4.34)		2.06 (0.98 – 4.34)
Ever been Bullied	Yes vs. No	1.79 (0.81 – 3.97)	2.36 (0.99 – 5.62)	1.60 (0.77 – 3.36)