Comparing the Effects of Aquaponics and Traditional Potted Horticulture on the Emotions of College Students

Yu-Chen Chien and Yu-Jou Liao

***Abstract*—Gardening therapy has been found to boost happiness and relieve emotional stress. As new adults, college freshmen are often challenged by stress and negative emotions arising from changes in their academic workloads, relationships, emotions, and finances. This experimental study measured changes of Design College in 60 freshmen's positive emotions across five stages of horticulture, i.e., seedling raising, seedling thinning, transplantation, maintenance and management, and harvest, each of which lasted for 50 minutes. The subjects' scores on the Positive Emotion Scale were highest for seedling cultivation (4.36/5), and lowest for harvest (3.91/5). This difference between the two stages was significant, while differences between the other stages were not. Aquaponics is combining aquaculture and hydroponic cultivation, and is also known as aquaculture symbiosis; Potted cultivation is associated with traditional continuous cropping in fields. In addition, 60 freshmen were divided into two groups with Aquaponics system and potted cultivation. It was found that, as compared to the 30 participants using traditional potted-horticulture methods, the 30 students engaged in aquaponic planting—which is based on fish and vegetable symbiosis—reported more positive energy and relaxation effects. However, these differences were not significant. The experimental results showed that freshmen's emotions were greatly influenced by three factors: design course, participant's coordination degree and operation content of each phase therapy.**

***Index Terms*—Horticulture therapy, positive affect schedule, aquaponics system, potted cultivation.**

I. Introduction

According to a 2016 John Tung Foundation survey of all age groups in Taiwan, which indicated that 18.7% of college students exhibited clear signs of depression [1]. The most likely reason for this finding was that for freshmen, college is their first experience of a non-family environment. Separated from their original family environments, often for the first time, students must arrange their lives independently, build new interpersonal relationships, and face academic and financial challenges, all while controlling their emotions; and not unexpectedly, freshmen—being the newest members of the undergraduate community—experience the most severe of these adjustment problems. Citing "dissatisfaction with school life", "lack of interest in study", "loneliness" and "bad relationship with family" [2], freshmen in the School of Design at Chaoyang University of Science and Technology have been found to suffer higher levels of emotional distress than those in other schools, and thus have been selected as the subjects of this study.

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Plants are intimately linked to human survival, and contact with trees and flowers can help people relax by disconnecting from their hectic, pressure-filled lives [3]. This has led to the emergence of formal horticultural therapy, which has been found to generate multiple positive benefits through joins people and plants in a close relationship of trust, characterized by the former's cooperation, interaction, and building of communication skills. Moreover, all living things are nourished and nurtured by water, and humans feel driven to be close to it, due to its deep association with vigor and vitality [4]. Basin cultivation, meanwhile, reminds people of their emotional connection to the land. Therefore, as well as exploring changes in freshmen's positive emotions during horticultural activity using the Positive Affect Schedule (PAS) [cite], this study compared the effectiveness of traditional potted horticulture against that of aquaponic cultivation in terms of its effects on the subjects' emotions. Accordingly, it will be guided by the following research questions:

1) Can any differences in college freshmen's emotional changes be observed across the aquaponics and traditional potted horticulture groups?
2) Is there any difference between the aquaponics and potted models in the positive emotional transition of college students?

II. Literature Review

A. Horticultural Therapy

Horticultural therapy, comprising the use of plants, gardening and natural environments, can complement traditional medical approaches to boosting bodily and mental health [5]. Specifically, the positive effects of contact with plants through planting and thinning seedlings, transplantation, maintenance/management and harvesting have been reported to include lowering of blood pressure; reduction in muscle tension; and perceptions of stress/pressure relief, improved thinking ability, happiness, and reduced fear [6]. In short, it is widely accepted that the process of taking care of plants can both restore bodily energy through physical activity, and psychologically, help establish, restore or enhance self-confidence, self-esteem, sense of achievement, self-worth, and positive emotions.

Likewise, simply looking at natural landscapes has been found to reduce stress and promote positive emotions, and even speed recovery from diseases [7]-[9]. This is generally explained using one of three theories: overload and arousal theory, learning theory, and evolution theory:

1) Overload and arousal: Modern people generally live in complex artificial environments, negative aspects of

which harm their sense perception, causing overstimulation and exhaustion of both body and mind. Low-conflict and uncomplicated plant-rich environments, in contrast, can relieve stress and provide benefits [10], [11].

2) Learning: Through the influence of past learning experiences, people know that, when in nature or otherwise close to plants, they will feel comfortable and happy, among other positive reactions [12], [13]. .

3) Evolution: Humans' preference for plant-rich and waterside environments is derived from the fact that their distant ancestors lived in such environments, collecting fruits, nuts and seeds and drinking water from streams. Therefore, walking in nature can bring about a sense of security and generate natural and peaceful behaviors, arising from instinctive reactions [14].

B. Positive Affect Schedule (PAS)

Emotion can be defined as the individual's overall cognitive assessment of his/her own emotional experience. This assessment process classifies emotional experience into different valences, such as positive and negative or happy and unhappy. Emotional experience can also be subdivided into emotions and moods, with the former occurring in short bursts, often triggered by external events. Moods, in contrast, are general emotional states that do not need to be triggered by any specific antecedent, and therefore tend to last longer. Positive emotional valence (e.g., pleasure and happiness) is subjective, but positive feedback can improve people's enthusiasm and ability to perform various activities [14]. The commonly used PAS (see Table I) is a self-report instrument that is filled out by subjects after an event of interest to the researcher, and yields their positive emotional status. Responses are all given on the same Likert-type five-point scale, from "strongly disagree" to "strongly agree", with 1 = "strongly disagree", 2 = "disagree", 3 = "somewhat agree", 4 = "agree", and 5 = "strongly agree". The higher scores the more positive emotion.

TABLE I: POSITIVE AFFECT SCHEDULE ITEMS

No	Item	Strongly disagree	Don't agree with	Sort of agree	Agree	Couldn't agree more
	scoring	(1)	(2)	(3)	(4)	(5)
1	I feel excited.					
2	I'm proud of myself.					
3	I feel happy.					
4	I'm in a relaxed mood.					
5	I'm interested in all kinds of things.					
6	My life makes me feel satisfied.					
7	I'm grateful for everything.					
8	I'm optimistic about the future					
9	I'm confident					
10	I love everything					

C. Aquaponics

"Aquaponics" is a new term, and a portmanteau word combining aquaculture and hydroponic cultivation, and is also known as aquaculture symbiosis. Its aim is the creation of sustainable micro-ecosystems that are mutually beneficial to their animal and vegetable components [15], [16], having the qualities of environmental friendliness, sociality and safety. It can be divided into three types by Tainan District Council of Agriculture in 2016: raft, media-filled bed (gravel), and a liquid nutrient film. Of these, the raft type is relatively common, user-friendly and the easiest to operate, and thus it was selected for use by this study.

D. Potted Cultivation

Potted cultivation, meanwhile, can effectively overcome the normal spatial requirements and overcome many of the disease and pest problems associated with traditional continuous cropping in fields for the growing of vegetables, while at the same time mitigating ongoing cultivation problems caused by animal pests and diseases. Therefore, for purposes of its central comparison, this study adopted rectangular pots measuring 60cm by 20cm for gardening in the shade. In theory, the earth of the potted plants should connect to people's emotional memory, while the water of the aquaponics system and the vitality of its fish should activate their senses.

III. RESEARCH METHODS

The study indicated a suitable sample size of at least 30 samples per group [17], [18]. Thus, a total of 60 design-school freshmen were recruited for the present study, and divided into two groups of 30: i.e., an aquaponics group and a potted-cultivation group. Each group was provided with a planting area of 6.37 m^2. Due to the limited time available, the researchers chose a short-term leafy vegetable, Brassica rapa chinensis. This study utilized a campus nursery with a planting area of 45.74 m^2 between February 25 and March 25, 2019. As briefly noted above, 60 college freshmen in design subjects were recruited and divided into two groups, one of which engaged in aquaponic cultivation, and the other, potted cultivation in rectangular pots measuring 60 x 21 x 19cm. Each participant planted 10 Chinese cabbage, and immediately after each of the five 50-minute stages of gardening operation, filled in a new PAS. The resulting emotional data were analyzed using SPSS 25.0 and Excel, followed by one-way analysis of variance (ANOVA) and independent-samples t-tests.

TABLE II: TEMPORAL RELATIONSHIP OF DESIGN COURSEWORK TO HORTICULTURAL OPERATIONS

Stage	Design- course assignment	Horticultural operation	Horticultural-operation content
1	Decide topic	Seeding	Place the medium into the hole tray for sowing and watering
2	First discussion	Thinning seedlings	Remove the seedlings with poor growth
3	Second discussion	Transplantation	Transfer plants from the hole trays to larger basins
4	Third discussion	Management/ Maintenance	Watering and fertilization
5	Homework due and report	Harvest	Crops cut and collected

The first stage was seedling cultivation, i.e., sowing or seeding; the second, seedling-thinning, consisted of pulling out those plants that were experiencing poor growth; and the third, transplantation, i.e., transferring the crops with two or three leaves into pots. The fourth stage, maintenance/management, consisted of watering and fertilization; and the fifth, of harvesting the plants. The PAS was filled in after stage 5 was completed. During the experiment, the subjects' main source of pressure was their design work, which corresponded to the cultivation stages as shown in Table II.

IV. Results and Discussion

The mean PAS result for all 60 subjects across all five horticultural stages was 4.18. The highest average score in any one stage was 4.36, for seeding, while the lowest was 3.91, for harvest (see Table III). This was the only significant PAS-score difference among all stages (see Table IV).

TABLE III: PAS Scores by Cultivation Stage, Both Group

Q ID	Stage 1 Seeding	Stage 2 Thinning seedlings	Stage 3 Transplantation	Stage 4 Management & Maintenance	Stage 5: Harvest	Item the average
	M	M	M	M	M	
	SD	SD	SD	SD	SD	
1	4.43	4.18	4.33	4.40	3.98	4.27(1)
	0.67	0.77	0.73	0.59	0.75	
2	4.30	4.00	4.30	4.30	3.97	4.17
	0.74	0.76	0.72	0.67	0.71	
3	4.35	4.13	4.35	4.37	4.02	4.24 (3)
	0.71	0.77	0.68	0.69	0.72	
4	4.47	4.18	4.37	4.37	3.88	4.25 (2)
	0.62	0.77	0.71	0.64	0.85	
5	4.38	4.18	4.25	4.32	3.83	4.19
	0.69	0.77	0.75	0.62	0.83	
6	4.38	4.03	4.28	4.32	3.92	4.19
	0.69	0.88	0.69	0.70	0.85	
7	4.40	3.97	4.23	4.25	4.00	4.17
	0.69	0.84	0.79	0.68	0.80	
8	4.25	3.93	4.20	4.17	3.82	4.07 (10)
	0.79	0.88	0.80	0.85	0.85	
9	4.35	3.92	4.23	4.20	3.77	4.09 (9)
	0.78	0.87	0.81	0.80	0.91	
10	4.32	3.87	4.28	4.17	3.88	4.10 (8)
	0.75	0.91	0.76	0.89	0.87	
The average	**4.36**	**4.04**	**4.28**	**4.29**	**3.91**	**4.18**

Note: (1), (2), and (3) indicate High marks, and (8), (9), and (10), Low grade.

As shown in Table III, the average values the participants assigned to each item ranged from a high of 4.47 for item 4, "I'm in a relaxed mood" during the seeding stage, to a low of 3.77 for item 9, "I'm confident" in the harvest stage. The mean PAS score for the aquaponics group across all 5stages was 4.19, as compared to 4.16 for their potted-cultivation counterparts. However, independent-samples t-tests showed that this difference was not significant (P=0.879>0.05) (see Table V).

TABLE IV: Post-hoc Analysis of Single-Factor Variance, for the Five Stages of Horticulture Therapy

Stage		MSD	P	Scheffe Post-hoc
Stage 1	Stage 2	0.3233	0.203	--
	Stage 3	0.0800	0.985	--
	Stage 4	0.0783	0.986	--
	Stage 5	0.4567	0.019	P=0.019<0.05, stage 1>stage 5
Stage 2	Stage 3	-0.2433	0.495	--
	Stage 4	-0.2450	0.488	--
	Stage 5	0.1333	0.907	--
Stage 3	Stage 4	-0.0017	1.000	--
	Stage 5	0.3767	0.090	--
Stage 4	Stage 5	0.3783	0.087	--

TABLE V: T-Test Results for Aquaponics and Potted-Cultivation Models

Model	N	M	SD	MSD	F	P	T	Significance (double-tailed)
Aquaponics	30	4.19	0.706	0.129	0.010	0.923	0.157	0.879
Potted cultivation	30	4.16	0.707	0.129				

A. Aquaponics Group Results

The mean PAS scores by stage for the 30 members of the aquaponics group are presented in Table VI. Their highest mean score for a stage was 4.33for maintenance/management, and for any particular item was 4.50 for item 1 ("I feel excited") within that stage. Their lowest for any item was 3.73 for item 5 ("I'm interested in all kinds of things") in the harvest stage, which also earned the lowest stage score, 3.94.

However, post-hoc comparisons using single-factor ANOVA found no significant differences among the five stages' PAS scores for this group (see Tables VI and VII).

TABLE VI: PAS Scores by Cultivation Stage, Aquaponics Group Only

Q ID	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Item average
	M	M	M	M	M	
	SD	SD	SD	SD	SD	
1	4.40	4.13	4.20	4.50	4.07	4.26 (2)
	0.72	0.78	0.85	0.57	0.64	
2	4.33	4.00	4.30	4.33	3.97	4.19
	0.71	0.74	0.75	0.76	0.72	
3	4.17	4.10	4.27	4.40	4.03	4.19
	0.75	0.71	0.78	0.67	0.72	
4	4.47	4.17	4.33	4.40	4.00	4.27 (1)
	0.57	0.75	0.71	0.62	0.79	
5	4.37	4.20	4.23	4.47	3.73	4.20

Q ID	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Item average
	M	M	M	M	M	
	SD	SD	SD	SD	SD	
	0.67	0.71	0.77	0.57	0.78	
6	4.30	4.10	4.27	4.43	4.03	4.23 (3)
	0.65	0.76	0.74	0.63	0.85	
7	4.30	4.03	4.10	4.27	4.00	4.14 (8)
	0.70	0.76	0.88	0.74	0.79	
8	4.23	4.10	4.20	4.13	3.77	4.09 (10)
	0.77	0.76	0.85	0.94	0.90	
9	4.43	4.13	4.37	4.27	3.87	4.21
	0.73	0.73	0.81	0.87	0.90	
10	4.23	4.10	4.23	4.07	3.97	4.12 (9)
	0.82	0.76	0.77	1.01	0.89	
The average	**4.32**	**4.11**	**4.25**	**4.33**	**3.94**	**4.19**

Note: (1), (2), and (3) indicate High marks, and (8), (9), and (10), Low grade.

TABLE VI: COMPARATIVE ANALYSIS OF SINGLE-FACTOR VARIANCE, AQUAPONICS GROUP ONLY

Stage		MSD	P	Scheffe Post-hoc
Stage 1	Stage 2	0.21667	0.855	--
	Stage 3	0.07333	0.997	--
	Stage 4	-0.00333	1.000	--
	Stage 5	0.38000	0.395	--
Stage 2	Stage 3	0-.21667	0.855	--
	Stage 4	-0.14333	0.964	--
	Stage 5	-0.22000	0.847	--
Stage 3	Stage 4	0.16333	0.943	--
	Stage 5	0.14333	0.964	--
Stage 4	Stage 5	-0.07667	0.997	--
Stage 1	Stage 2	0.30667	0.614	--
	Stage 3	0.38333	0.386	--

B. Potted-Horticulture Group Results

Among the 30 potted-cultivation group members, the seeding stage yielded the highest mean PAS score, 4.36. Harvest was again the lowest-scoring stage, at 3.87, but transplantation also scored below 4.00, i.e., 3.97 (see Table IX), or about the same as the lowest-scoring stage in the aquaponics condition. The highest mean score assigned by the potted-cultivation group to any item in the PAS was 4.70, received in stage 1 by both item 3 ("I feel happy") and item 7 ("I'm grateful for everything"); and the lowest, 3.63 for item 10 ("I love everything") in stage 2 (see Table VIII).

TABLE VIII: PAS SCORES BY CULTIVATION STAGE, POTTED-CULTIVATION GROUP ONLY

Q ID	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Item average
	M	M	M	M	M	
	SD	SD	SD	SD	SD	
1	4.63	4.23	4.47	4.30	3.90/	4.27 (2)
	0.49	0.77	0.57	0.60	0.84	
2	4.47	4.00	4.30	4.27	3.97	4.16
	0.68	0.79	0.70	0.58	0.72	
3	4.70	4.17	4.43	4.33	4.00	4.29 (1)
	0.47	0.83	0.57	0.71	0.74	
4	4.67	4.20	4.40	4.33	3.77	4.23 (3)
	0.48	0.81	0.72	0.66	0.90	
5	4.60	4.17	4.27	4.17	3.93	4.19
	0.56	0.83	0.74	0.65	0.87	
6	4.67	3.97	4.30	4.20	3.80	4.15
	0.55	1.00	0.65	0.76	0.85	
7	4.70	3.90	4.37	4.23	4.00	4.20
	0.47	0.92	0.67	0.63	0.83	
8	4.47	3.77	4.20	4.20	3.87	4.06 (9)
	0.73	0.97	0.76	0.76	0.82	
9	4.47	3.70	4.10	4.13	3.67	3.97 (10)
	0.73	0.95	0.80	0.73	0.92	
10	4.60	3.63	4.33	4.27	3.80	4.09 (8)
	0.50	1.00	0.76	0.74	0.85	
The average	**4.6**	**3.97**	**4.32**	**4.24**	**3.87**	**4.2**

Note: (1), (2), and (3) indicate High marks, and (8), (9), and (10), Low grade

TABLE IX: COMPARATIVE ANALYSIS OF SINGLE-FACTOR VARIANCE, POTTED-CULTIVATION GROUP ONLY

Stage		MSD	P	Scheffe Post-hoc
Stage 1	Stage 2	0.43000	0.273	--
	Stage 3	0.08667	0.995	--
	Stage 4	0.16000	0.949	--
	Stage 5	0.53333	0.098	--
Stage 2	Stage 3	-0.34333	0.509	--
	Stage 4	-0.27000	0.727	--
	Stage 5	0.10333	0.990	--
Stage 3	Stage 4	0.07333	0.997	--
	Stage 5	0.44667	0.236	--
Stage 4	Stage 5	0.37333	0.421	--

V. CONCLUSION

This research used the PAS to investigate the relative effects of aquaponics and potted cultivation of Brassica rapa chinensis on Taiwanese college freshmen's positive emotions over a five-week period. The results of the present study indicate that, across both types of therapy that the participants engaged in, positive emotions were evoked most strongly

during the first (seeding) stage, and least strongly in the fifth (harvest) stage. Though this difference was significant, all other inter-stage difference in PAS scores were not. This could have been related to the novelty of the horticultural experience, and/or to the fact that the seeding stage coincided with a relatively un-stressful phase of their freshman design course. Likewise, as the amount and difficulty of their design homework gradually increased across the stages, such external pressures could have negatively impacted the subjects' average PAS scores. There was no significant difference in mean PAS scores between the aquaponics and potted-cultivation groups, though those of the former were slightly higher. The PAS items "I'm excited", "I'm happy" and "My mood is relaxed" tended to receive consistently high scores, irrespective of group membership or cultivation stage, while "I'm optimistic about the future", "I'm confident", and "I love everything" were consistently assigned low scores. This may suggest that the subjects' participation in horticultural therapy, while beneficial to short-term emotional states, had a less obvious impact on their long-term moods. Conducting future research over a longer time period would help to resolve this question.

The aim of this study was to explore the changes of emotions benefits of freshmen through different cultivation methods. The experimental results showed that freshmen's emotions were greatly influenced by three factors: design course, participant's coordination degree and operation content of each phase therapy. Intro:

A. Influence of Study

The design course with the largest number of mark assignments in the middle school of freshman year is influenced by the experimental operation time of course, which is mainly in line with the participant's design course. Students spend more time and effort, and feel more pressure and emotions may be affected by the course. In the course of Decide topic, Homework due and report, and participant's psychological emotions are all obviously subject to the change of the amount of work and the degree of difficulty. It is suggested that this factor be included as a variable for future research or to reduce this interference factor.

B. Participate in the Cooperation Degree

For freshmen, the design course is a full day course, with more time to cooperate with the gardening operation experiment. In addition, during the 50-minute experiment of Horticulture therapy at each stage, participants' sense of participation and coordination gradually decreased with the increase of work quantity of design course and the decrease of freshness of gardening operation. The purpose of the study is to relax the mind. Therefore, it is suggested to understand the causes of low participation intention and increase coordination through encouraging words or influence of peers.

C. Horticulture Therapy Operation Content

The content of the exercise is mainly aimed at relaxing mood, promoting interpersonal interaction and easy operation, and keeping participants' positive emotion. Even though the participants differ in patience and carefulness, they have different cognition and self-evaluation of the goal to be achieved at each phase. The content of the experiment should be more carefully arranged and set.

The practice of Horticulture therapy emphasizes more the benefit of keeping the spirit of joy and interaction throughout the process. Freshmen felt frustrated or impatient during the experiment, no matter influenced by study, participation and activity content. The study suggested that participants be given more opportunities to encourage, catharsis and enlighten emotions through interpersonal interaction.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

A conducted the research, B analyzed the data, A and B wrote the paper; all authors had approved the final version.

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