創造力認知歷程之解構與重構：以數位遊戲為媒介

計畫編號：NSC 100－2511－S－004－002－MY3
執行期間： 100 年 8 月 1 日至 103 年 7 月 31 日

研究一：數位遊戲導向創造力評量系統和三維情緒量表之發展

本研究第一年的主要目的在操弄壓力，以探討大學生的壓力荷爾蒙、情緒、工作記憶和數位遊戲導向創造力表現之關係。因此，本研究第一年發展了數位化工作記憶作業（語文和圖形）和數位遊戲導向創造力作業，並將這些研究工具整合為一套完整的數位化評量系統。此外，本研究發展了三維情緒量表以測量主觀的情緒感受。

一、 研究參與者

本研究參與者為301為大學生，男生為101人(35.3%)，女生為185(64.7%)，遺漏值為15人。參與者的平均年齡19.75歲(*SD* = 1.99歲)。

二、 研究工具

本研究根據Bass、De Dreu和Nijstad (2008)的理論，發展三維情緒量表(Inventory of Three-dimension Emotions, I3E)，並將情緒分為三個向度：（1）快樂調性（hedonic tone或情緒價數（valence）：包括正向和負向；（2）活化程度（activation）：包括高活化和低活化；（3）調節焦點（regulatory focus）：包括預防和促進。I3E包含的情緒分布見表1。

I3E為李克特式4點量表，以「1」至「4」分代表「非常不同意」至「非常同意」。I3E共包含16題，每個向度個包含2題，作答無時間限制。

表1：三維情緒量表之題目分布

正向				負向			
低活化		高活化		低活化		高活化	
預防	促進	預防	促進	預防	促進	預防	促進
平靜	安全	有活力	快樂	疏離	悲傷	焦慮	生氣
放鬆	信任	溫暖	振奮	疲累	失望	緊張	挫敗

三、 研究過程

本研究委託大學任課教師於課堂中將紙本的 I3E 發給修課學生，並於完成填答後立即收回。本問卷的填答無時間限制。

四、 資料分析

本研究首先以 AMOS 19.0 軟體進行驗證性因素分析（confirmatory factor analysis，CFA），確認兩個 I3E 模式之建構效度。之後，以 SPSS 19.0 進行 I3E 的信度分析並進行描述統計分析。

五、 研究結果

（一） 驗證性因素分析

本研究首先以 CFA 確認 I3E 的建構效度。本研究以 301 位大學生為參與者，並以最概似估計法（maximum likelihood, ML）進行參數估計來檢驗量表的因素效度。本研究將以 I3E 正向情緒與負向情緒分別進行 CFA。在二階測量模式的設定上，第一階的潛在因素為高活化與低活化，第二階的潛在因素為預防與促進。

1. 模式適配度考驗

依余民寧（2006）建議，本研究從整體適配度、比較適配度與精簡適配度三方面進行結構方程模式（structural equations model, SEM）之評鑑，模式適配分析結果列於表2與表3。本研究發現正向情緒模式與觀察資料適配的卡方考驗$\chi^2(17, N = 301) = 57.134$，$p = .000$（見表3）；負向情緒模式與觀察資料適配的卡方考驗$\chi^2(15, N = 301) = 29.151$，$p = .015$（見表2）。模式分析的結果見圖4與圖5。兩個模式分析結果皆顯示觀察所得之共變數矩陣與理論上的共變數矩陣均等的假設須予以拒絕，亦即理論模式與觀察資料並不適配；換言之，本研究所提出的兩個分析模式並沒有與觀察資料適配。然而，卡方檢定對樣本數相當敏感，一旦樣本過大或資料偏離多變量常態分配就容易造成卡方統計上升而導致拒絕虛無假設（H_0）。一般認為卡方檢定不適合成為模式考驗的唯一指標，尚須參考其他重要適配指標作為評鑑之依據（Jöreskog & Sörbom, 1993）。

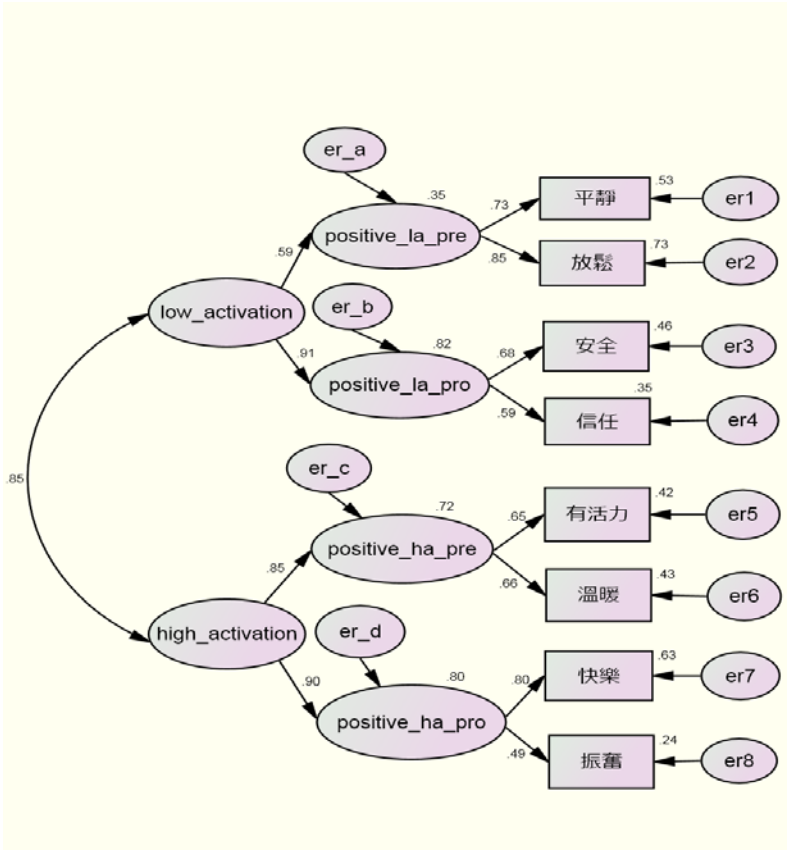

圖4：I3E正向情緒模式驗證性因素分析模式

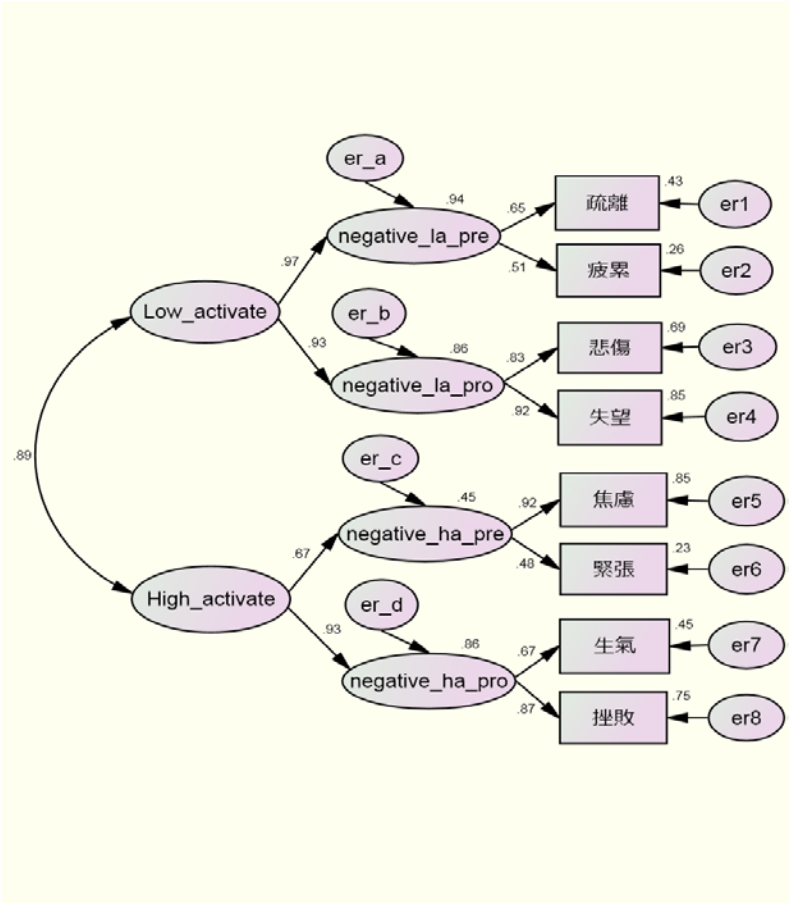

圖5：I3E負向情緒模式驗證性因素分析模式

本研究參酌其他重要的適配度指標，正向情緒模型的分析結果顯示，均方接近似誤（RMSEA）= .089，稍高於標準.05；GFI = .956，AGFI = .906；RMR = .022，低於標準值.05；NC（正規化卡方值）為χ^2/df = 3.361，稍高於1至3之間的理想適配值(吳明隆，2009、榮泰生，2007)。綜上顯示本研究建構的I3E正向情緒分析模式有良好的整體適配度。此外，此模式的CFI = .927、IFI = .929、NFI = .901、RFI = .838，皆達到.90的標準或接近.90的標準，表示I3E正向情緒分析模式具有非常好之比較適配度(見表3)。

在負向情緒分析模式中，RMSEA為.056，稍高於標準.05；GFI = .976，AGFI = .944；RMR = .017，低於標準值.05；NC = 1.943，介於1至3之間的理想適配值(吳明隆，2009、榮泰生，2007)。綜上顯示本研究建構的I3E負向情緒分析模式有良好的整體適配度。此外，此模式的CFI = .984、IFI = .985、NFI = .969、RFI = .942，皆達到.90的標準，表示I3E負向情緒分析模式具有非常好之比較適配度。

綜上所述，本研究所建構的兩個I3E正、負向情緒模式在整體適配度的考驗上以及比較適配度指標都顯示理論模式和觀察資料有相當的適配度，亦即理論模式可以用來解釋實際的觀察資料。

表2 ：I3E負向情緒理論模式之適配度指標摘要表

適配指標	分析結果	判斷規準與解釋
整體適配度指標		
χ^2	29.151	
df	15	
P	.015	>.05，適配
GFI	.976	>.90，適配
AGFI	.944	>.90，適配
RMR	.017	<.05，適配
RMSEA	.056	<.05，合理適配
比較適配度指標		
CFI	.984	>.90，適配
NFI	.969	>.90，適配
IFI	.985	>.90，適配
RFI	.942	>.90，適配
精簡適配度指標		
NC（Normed χ^2）	1.943	1<NC<3較好
PNFI	.519	越高較好
PCFI	.527	越高較好
AIC	71.151	愈小愈好

表 3 ：I3E 正向情緒理論模式之適配度指標摘要表

適配指標	修正後分析結果	判斷規準與解釋
整體適配度指標		
χ^2	57.134	
df	17	
p	.000	>.05，適配
GFI	.956	>.90，適配
AGFI	.906	>.90，適配
RMR	.022	<.05，適配
RMSEA	.089	<.05，合理適配
比較適配度指標		
CFI	.927	>.90，適配
NFI	.929	>.90，適配
IFI	.901	>.90，適配
RFI	.838	>.90，適配
精簡適配度指標		
NC（Normed χ^2）	3.361	1<NC<3較好
PNFI	.547	越高較好
PCFI	.563	越高較好
AIC	95.134	愈小愈好

2. 組合信度與平均變異解釋量

本研究以第一階斜交模式的參數估計結果來檢驗正向情緒模式題目的聚斂效度(convergent validity)，發現各觀察變項對其個別潛在變項的因素負荷量（λ），也就是完全標準化估計值，是介於.494~.895之間，顯示觀察變項能反映其所建構的潛在變項；標準誤(SE)介於.093～.277之間；解釋量(R^2)介於.244～.822之間；誤差變異量(error variance, Delta = 1-R^2)介於.178～.756之間。此外，以組合信度（ρ_c）和平均變異解釋量（average variance extracted, ρ_v）來檢視量表的信度與聚斂效度(convergent validity)，發現正向情緒模式第一階的組合信度為.579~.866，指標值均大於.50，亦即具有測量某個潛在變項或理論建構的理想組合信度。另一方面，平均變異解釋量為.408~.763，指標值均接近或大於.50以上，表示潛在變項被某個變項或理論建構解釋的量，高於被測量誤差所解釋到的變異量，顯示本量表的內部品質良好（見表4）。

以第一階斜交模式的參數估計結果來檢驗負向情緒模式題目的聚斂效度，發現各觀察變項對其個別潛在變項的因素負荷量（λ）介於.479~.972之間，顯示觀察變項能反映其所建構的潛在變項；標準誤介於.075～.137之間；解釋量介於.229～.945之間；誤差變異量介於.055～.739之間。此外，負向情緒模式的組合信度為.508~.948，指標值均大於.50，亦即具有測量某個潛在變項或理論建構的理想組合信度。另一方面，平均變異解釋量為.344~.902，指標值均接近或大於.50以上，表示潛在變項被某個變項或理論建構解釋的量，高於被測量誤差所解釋到的變異量，顯示本量表的內部品質良好（見表5）。

表4 ：I3E正向模式二階驗證性因素分析之參數估計摘要表

題號	λ	SE	t	R^2	Delta $=1-R^2$	組合信度	平均變異解釋量
正向低活化						.731	.587
正向_預防	.593			.352	.648		
正向_促進	.907	.277	5.273	.822	.178		
正向高活化						.866	.763
正向_預防	.851			.725	.275		
正向_促進	.895	.164	7.549	.802	.198		
正向_低活化_預防						.771	.629
e1	.727			.528	.472		
e2	.854	.182	7.143	.730	.270		
正向_低活化_促進						.579	.408
e24	.681			.464	.536		
e9	.594	.134	6.766	.353	.647		
正向_高活化_預防						.598	.427
e23	.649			.421	.579		
e11	.658	.126	7.493	.432	.568		
正向_高活化_促進						.598	.440
e3	.797			.634	.366		
e4	.494	.093	6.734	.244	.756		

表5 ：I3E負向模式二階驗證性因素分析之參數估計摘要表

題號	λ	SE	t	R^2	Delta $= 1-R^2$	組合信度	平均變異解釋量
正向低活化						.948	.902
負向_預防	.972			.945	.055		
負向_促進	.927	.119	9.238	.859	.141		
正向高活化						.788	.656
負向_預防	.672			.452	.548		
負向_促進	.928	.108	7.712	.861	.139		
負向_低活化_預防						.508	.344
e13	.653			.426	.574		
e14	.511	.122	7.449	.261	.739		
負向_低活化_促進						.867	.766
e16	.828			.686	.314		
e18	.920	.075	16.661	.846	.154		
負向_高活化_預防						.681	.540
e5	.922			.850	.150		
e8	.479	.095	5.498	.229	.771		
負向_高活化_促進						.749	.602
e6	.674			.454	.546		
e7	.866	.137	10.833	.750	.250		

(二)內部一致性信度分析及因素相關

CFA 分析完成後，I3E 題目包含八個向度：正向_低活化_預防、正向_低活化_促進、正向_高活化

_預防、正向_高活化_促進、負向_低活化_預防、負向_低活化_促進、負向_高活化_預防、負向_高活化_促進。本研究以正向情緒 8 題題進行內部一致性信度分析發現，其校正題目--總分的相關係數在.020~.621，*p*s < .01。以負向情緒 8 題題進行內部一致性信度分析發現，其校正題目--總分的相關係數在.091~.762，*p*s < .01。

就 Cronbach's α 係數而言，正向低活化的 Cronbach's α 係數為.686、正向高活化為.706、正向預防為.624、正向促進為.636；全部正向情緒的 Cronbach's α 係數為.771。負向低活化的 Cronbach's α 係數為.795、負向高活化為.723、負向預防為.646、負向促進為.842；全部負向情緒的 Cronbach's α 係數為.839(見表 6)。

表 6： I3E 的 Cronbach's α 係數

正向(α = .771)				負向(α = .842)			
低活化(α = .686)		高活化(α = .706)		低活化(α = .795)		高活化(α = .723)	
預防	促進	預防	促進	預防	促進	預防	促進
(α = .766)	(α = .576)	(α = .494)	(α = .543)	(α = .500)	(α = .866)	(α = .613)	(α = .737)

此外，正向情緒一階因素的相關係數為.467，二階因素間的相關係數為.278~.575，一階與二階因素間的相關係數為.305~.891，顯示因素間具有中度到高度相關(見表 7)。負向情緒一階因素的相關係數為.606，二階因素間的相關係數為.390~.629，一階與二階因素間的相關係數為.491~.897，顯示因素間具有中度到高度相關（見表 8）。

表 7 ：I3E 正向情緒因素相關矩陣(*N*=301)

因素	1	2	3	4	5	6
二階因素						
正向_低活化_預防(1)	1					
正向_低活化_促進(2)	.363***	1				
正向_高活化_預防(3)	.278***	.463***	1			
正向_高活化_促進(4)	.264***	.377***	.575***	1		
一階因素						
低活化(5)	.841***	.809***	.444***	.385***	1	
高活化(6)	.305***	.472***	.884***	.891***	.467***	1

**** p <.001.*

表 8 ：I3E 負向情緒因素相關矩陣(*N*=301)

因素	1	2	3	4	5	6
二階因素						
負向_低活化_預防(1)	1					
負向_低活化_促進(2)	.601***	1				
負向_高活化_預防(3)	.390***	.388***	1			
負向_高活化_促進(4)	.448***	.629***	.448***	1		
一階因素						
低活化(5)	.892***	.897***	.435***	.603***	1	
高活化(6)	.491***	.592***	.862***	.839***	.606***	1

**** p <.001.*

(三)大專院校學生情緒現況及性別差異

本研究以八個情緒因素為依變項的 MANOVA 分析顯示：不同性別的參與者在整體情緒表現無顯著差異，Wilks' Λ = .947, p = .055, η_p^2 = .053。但分別以八個情緒因素為依變項的 ANOVA 分析顯示：不同性別的參與者在正向_低活化_預防、正向_低活化_促進、正向_高活化_預防、負向_低活化_促進、負向_高活化_促進情緒有顯著差異，Fs (1, 284) = 4.985~6.534，ps < .05。由平均數的比較發現，在三個正向情緒向度上，皆為女生的得分高於男生，但在二個負向情緒向度上，皆為男生的得分高於女生。

表9： 三維情緒量表的性別差異考驗

Source	Descriptive			ANOVA F(1, 284)			
	M	*SD*	*N*	*MS*	*F*	*P*	η_p^2
正向_低活化_預防							
男	2.86	0.63	101	1.668	5.469*	.020	.019
女	3.02	0.51	185				
Total	2.96	0.56	286				
正向_低活化_促進							
男	2.81	0.55	101	1.312	4.985*	.026	.017
女	2.95	0.49	185				
Total	2.90	0.52	286				
正向_高活化_預防							
男	2.51	0.47	101	1.266	4.987*	.026	.017
女	2.65	0.52	185				
Total	2.60	0.51	286				
正向_高活化_促進							
男	2.35	0.53	101	.611	2.182	.141	.008
女	2.44	0.53	185				
Total	2.41	0.53	286				
負向_低活化_預防							
男	2.34	0.64	101	.284	.695	.405	.002
女	2.28	0.64	185				
Total	2.30	0.64	286				

Source	Descriptive			ANOVA *F*(1, 284)			
	M	*SD*	*N*	*MS*	*F*	*P*	η_p^2
負向_低活化_促進							
男	1.82	0.74	101	2.547	5.814*	.017	.020
女	1.62	0.61	185				
Total	1.69	0.67	286				
負向_高活化_預防							
男	2.09	0.65	101	.046	.111	.740	.000
女	2.07	0.64	185				
Total	2.08	0.64	286				
負向_高活化_促進							
男	1.68	0.66	101	2.257	6.534*	.011	.022
女	1.50	0.55	185				
Total	1.56	0.59	286				

* $p < .05$.

六、討論與結論

本研究根據 Bass、De Dreu 和 Nijstad (2008）的理論，發展三維情緒量表(Inventory of Three-dimension Emotions, I3E)，並將情緒分為三個向度：（1）快樂調性（hedonic tone 或情緒價數（valence）：包括正向和負向；(2)活化程度(activation)：包括高活化和低活化；(3)調節焦點(regulatory focus)：包括預防和促進。驗證性因素分析、內部一致性分析、相關分析的結果顯示所發展量表具有良好的信度與效度。過去的情緒量表多採一維活二維向度，從三維向度取向的角度來看情緒意涵，不但可以了解情緒的正、負向取向、活化程度，還能從預防與促進的觀點了解情緒對於個體生存與發展所具備的意義功和能，有其實用價值。

本研究發現，不同性別的參與者在整體情緒表現上無顯著差異，但進一步分析發現在正向_低活化_預防、正向_低活化_促進、正向_高活化_預防三個正向情緒向度上，皆為女生的得分高於男生，在負向_低活化_促進、負向_高活化_促進二個負向情緒向度上，皆為男生的得分高於女生。顯示女生較男生具有正向的情緒狀態。

情緒狀態檢核表

姓名：_____ 學號：_____ 性別： □ 男 □ 女　年齡(實歲)：_____

您目前就讀：1.□大學　2.□碩士班 3.□博士班

所屬學院： 1.□文(外語)　2.□理　3.□工　4.□社科(教育)　5.□法　6.□商(管、傳播)

7.□醫　8.□農　9.□藝術　0.□其他

請依您現在的感受感受程度回答下列問題

我現在覺得		非常不同意	不同意	同意	非常同意	我現在覺得		非常不同意	不同意	同意	非常同意
1	平靜……	1	2	3	4	9	信任……	1	2	3	4
2	放鬆……	1	2	3	4	10	溫暖……	1	2	3	4
3	快樂……	1	2	3	4	11	疏離……	1	2	3	4
4	振奮……	1	2	3	4	12	疲累……	1	2	3	4
5	焦慮……	1	2	3	4	13	悲傷……	1	2	3	4
6	生氣……	1	2	3	4	14	失望……	1	2	3	4
7	挫敗……	1	2	3	4	15	有活力……	1	2	3	4
8	緊張……	1	2	3	4	16	安全……	1	2	3	4

Computers in Human Behavior 55 (2016) 817–825

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Full length article

The dynamic influence of emotions on game-based creativity: An integrated analysis of emotional valence, activation strength, and regulation focus

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ARTICLE INFO

Article history:
Received 5 November 2014
Received in revised form
7 October 2015
Accepted 30 October 2015
Available online xxx

Keywords:
Creativity
Game-based learning
Negative emotion
Positive emotion
Regulation focus

ABSTRACT

Emotion has been identified as an important predictor of creativity, but little attention has been put on investigating how emotion, especially that considers regulation focus, may dynamically influence male and female students' creativity in game-based situations. To explore the dynamic relationship between various types of emotions and creativity during game playing, 266 college students were included and the Creativity Game-based Evaluation System (CGES) was developed in this study. Four types of emotions integrating perspectives of valence (positive vs. negative), activation (high vs. low), and regulatory focus (prevention vs. promotion) were investigated in this study: the positive-low activation-prevention emotion (P-L-Pre) (calm and relaxed), the positive-high activation-promotion emotion (P-H-Pro) (happy and elated), the negative-high activation-prevention emotion (N-H-Pre) (nervous and anxious), and the negative-high activation-promotion emotion (N-H-Pro) (frustrated and angry). The results revealed that, although there was a slight gender difference in game-based creativity, the prediction patterns of emotions in game-based creativity were very similar among participants with different genders. Specifically, emotions during game playing can better predict creativity than those of the baseline; moreover, the P-H-Pro emotion can facilitate performance on creativity, whereas the N-H-Pro emotion can decrease creativity performance. Thus, providing appropriate challenges to induce highly-activated and promotion-focused positive emotions are critical for the success of games designed to improve creativity.
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1. Introduction

Games have been defined as an immersive, voluntary, and enjoyable activity in which a challenging goal is pursued (Freitas & Oliver, 2006; Kinzie & Joseph, 2008). Many studies have found that educational games can enhance learning motivation and learning outcomes (e.g., Dickey, 2011; Hung, Hwang, Lee, & Su, 2012; Sung & Hwang, 2013). On the other hand, creativity is an important educational goal in this rapidly changing society. Despite substantial research on creativity in recent decades, studies that integrate creativity and games are still limited. Among the game-free creativity research, emotions are one of the most influential factors on creativity performance. However, the findings on how emotions influence creativity are not consistent. Some studies suggest that positive emotions can facilitate creativity (e.g., Forgeard, 2011; Hutton & Sundar, 2010; Isbister, 2011), whereas other studies suggest that negative emotions can enhance creativity (e.g., Hirt, Devers, & McCrea, 2008; Jones & Kelly, 2009). Moreover, some studies claim that in addition to valence (positive vs. negative), the arousal level of emotions is important (De Dreu, Baas, & Nijstad, 2008; Zenasni & Lubart, 2008). More recently, researchers have suggested that valence, activation level, and regulation focus (prevention vs. promotion) all need to be taken into account when exploring the influence of emotions on creativity (Baas, De Dreu, & Nijstad, 2008; Yeh, 2012).

To date, only a few studies have investigated the relationship of flow experience or enjoyment (positive emotions) and creativity

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http://dx.doi.org/10.1016/j.chb.2015.10.037
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(Boyle, Connolly, & Hainey, 2011; Chang, Wu, Weng, & Sung, 2012); few studies have focused on understanding the relationship between various types of emotions and creativity in game-based learning or their dynamic relationship during game playing, not to mention those explore gender differences. It has been suggested that there are gender difference in creativity performance (Lin, Hsu, Chen, & Wang, 2012; Naderi, Abdullah, Aizan, Sharir, & Kumar, 2009), gaming (Homer, Hayward, Frye, & Plass, 2012; Yang & Chen, 2010), and emotions (Simon, 2014; Tolegenova, Kustubayeva, & Matthews, 2014; Zhao, Zhang, & Zheng, 2014). Thus, this study mainly aimed at exploring the dynamic relationship between various types of emotions and creativity in game-based situations from an integrated perspective of emotions. Meanwhile, gender differences in such a dynamic relationship were also examined.

1.1. Game-based learning and creativity

Numerous definitions of creativity have been proposed (e.g., Kampylis, Berki, & Saariluoma, 2009; Zeng, Proctor, & Salvendy, 2011) over the past six decades. In a review article, Hennessey and Amabile (2010) suggested that creativity involves the development of a novel product, idea, or problem solution that is valuable to the individual and/or the larger social group. Yeh (2011) also proposed that creativity is a process of producing original and valuable products within a specific cultural context. To ensure originality or novelty, some researchers (Dineen, Samuel, & Livesey, 2005) have claimed that appropriateness and convergent thinking, as well as divergent and productive thinking, are necessary for creativity. In cognitive psychology, many researchers use insight problems to test creativity, as it enables researchers to experimentally examine the process of creativity within a relatively short time period (Abraham & Windmann, 2007). Insight problems, which typically include open problems and closed solutions, involve restructuring a problem before the problem can be solved (Abraham & Windmann, 2007). Therefore, this study employed insight problems to measure an individual's creativity during playing games.

Recently, game-based learning has attracted researchers' attention, as it is effective in engaging players in learning (Bayliss, 2007; Prensky, 2003). Games usually include clear objectives, and they often provide tasks with multiple difficulty levels to adapt to the prior knowledge and skills of learners; therefore, games are considered as an effective educational tool (Gentile & Gentile, 2008). As information technology is rapidly developing, games have become interactive; they provide a complete playing environment that motivates learners through fun, challenge, and instant visual feedback (Mitchell & Savill-Smith, 2004).

Although some researchers (Kiili, 2005; MacDonald, Stodel, Farres, Breithaupt, & Gabriel, 2001) have suggested that games can support the learning of creativity, few researchers have developed games for evaluating or enhancing creativity. Faiola, Newlon, Pfaff, and Smyslova (2012) found that game-based learning can enhance learning experience while promoting exploration and creativity. In the same vein, Michalewicz and Michalewicz (2007) found that puzzle-based learning can support problem-solving skills and creative thinking. Thus, games can be employed to enhance the development of creativity and motivate the learner to solve problems through his or her interactions with game scenarios; during the process, the learner may link the abstract concept to the concrete game experience in an attempt to solve a problem (Lenga, Alib, Mahmudb, & Baki, 2010). However, the role of emotions has not been investigated in these game-based studies.

1.2. Emotions and creativity in game-based learning

1.2.1. Emotions and creativity

Among the influential factors on creativity, emotion has been the most widely studied predictor of creativity (Baas et al., 2008). Many studies have examined the relationships between emotions and creativity from the perspective of valence (positive emotions vs. negative emotions). Some findings suggest that a positive emotional state facilitates creativity, as it enhances cognitive flexibility and association network (Baas et al., 2008; Forgeard, 2011; Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Hutton & Sundar, 2010; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2009). In contrast, other findings suggest that a negative emotional state enhances creativity, as it indicates that the current situation is problematic and therefore motivates actions to solve the problem (Baruch, Grotberg, & Stutman, 2008; Carlsson, 2002; Hirt et al., 2008; Jones & Kelly, 2009; Zenasni & Lubart, 2009). Other findings suggest that the positive and negative emotions may exist simultaneously and facilitate creativity when the emotion is appropriately used and when the situation is novel (Fong, 2006; Kaufmann & Vosburg, 1997).

Researchers have also investigated the relationship between emotions and creativity from the perspective of arousal. While some findings suggest that highly aroused negative emotions decrease the production of original ideas (Zenasni & Lubart, 2008), other findings suggest that activating moods (e.g., angry, happy) lead to more creativity than deactivating moods (De Dreu et al., 2008).

These inconsistent findings may indicate that examining the relationship between emotions and creativity from the unidimensional (valence or activation level) perspective may oversimplify their relationship. The three-dimensional theory of emotion (Baas et al., 2008) may help to illuminate the complex relationship between emotions and creativity. The three dimensions include hedonic tone (positive vs. negative), level of activation (activating vs. deactivating), and regulatory focus (promotion vs. prevention). According to Baas et al. (2008), emotional states that are related to a promotion focus (e.g., anger, happiness) expand attentional scope and thus facilitate creative performance, whereas emotional states that are associated with a prevention focus (e.g., fear, relaxation) constrict attentional scope and therefore impede creative performance.

According to the social cognitive perspective, self-regulation learning includes three cyclist and interactive phase: (1) forethought: it involves task analysis and self-motivation beliefs; (2) performance: it involves self-control and self-observation; and (3) self-reflection: it involves self-judgment and self-reaction. During the process of self-reaction, feelings of self-satisfaction and emotion may motivate efforts to learn. Self-reaction may also involve adaptive inferences which influence approaches for subsequent learning. Moreover, the self-reflection reactions influence the goal setting, planning, and motivational beliefs regarding further efforts to learn in the forethought phase (Zimmerman, 2011). These arguments explain the importance of including regulation focus in emotions.

1.2.2. Emotions, and game-based creativity

It has been suggested that emotion is related to learning achievement in game-based learning (Chu, Hwang, Tsai, & Tseng, 2010; Fu, Su, & Yu, 2009). The Understanding of players' emotions, such as subjective feelings, anxiety, and enjoyment, has recently attracted attention from researchers (Fu et al., 2009; Jennett et al., 2008). Some researchers (Boyle et al., 2011) have claimed that enjoyment is the main emotion experienced when playing games. Thus, a measure of enjoyment in educational games

that assesses eight dimensions of enjoyment has been developed. The measured dimensions are as follows: immersion, social interaction, challenge, goal clarity, feedback, concentration, control, and knowledge improvement (Fu et al., 2009). Similarly, it has been suggested that games are designed to generate a positive emotion in players and that games are most successful and engaging when they facilitate the flow experience (Kiili, 2005). "Flow experience" is a highly enjoyable state of consciousness that occurs when a player's skills match the challenges; it involves a feeling of enjoyment and psychological immersion, energized focus, and involvement is often accompanied by positive emotions or a sense of pleasure (Faiola et al., 2012). Previous research has shown that the flow state has a positive impact on learning (Faiola et al., 2012; Kiili, 2005) and that it should be taken into account when designing digital games. Empirical studies (Chang et al., 2012; Faiola et al., 2012) have found that game-based learning can facilitate flow experience and problem-solving.

However, some researchers have suggested that negative emotions (e.g., anxiety) may strengthen players' enjoyment while they are playing fast-paced games (Jennett et al., 2008). Some studies have also examined a variety of physiological correlates of emotions in the game. For example, Baldaro et al. (2004) demonstrated that increases in blood pressure changes heart rate when playing games. Psychological studies, however, have inconsistent viewpoints toward how negative emotions influence creativity. For example, De Dreu et al. (2008) suggested that stressors may increase emotional arousal, which further enhances the use of creative thoughts and motivates persistence toward finding solutions. On the other hand, Byron, Khazanchi, and Nazarian (2010) found severe stressor may hinder creativity from a meta-analysis study. Accordingly, emotions may have strong influences on game-based creativity, regardless of influence directions.

1.2.3. Gender differences in emotions and game-based creativity

The role of gender in creativity has been explored to determine whether males and females differ in performance of creativity. To date, related findings are inconclusive (e.g. Baer & Kaufman, 2008; Naderi et al., 2009; Runco, Cramond, & Pagnani, 2010). Moreover, little empirical evidence of gender differences on domain-general creativity has been found (Abraham, 2015). However, in a recent cognitive neuroscience study, it was found that there were gender differences of changes in the power of bioelectric potentials, suggesting that the neurophysiological mechanisms of creativity are different in men and women (Volf & Tarasova, 2013).

In game-based situations, few studies have investigated gender differences in creativity. However, some studies have found gender differences in attitudes and strategies during gaming. In a sharing game, Zin, Escobal, Esteves, and Goyos (2015) found that males chose more optimized alternatives than females in the economic sense. In an investigation of attitudes for computer games, it was found that males had a more positive attitude toward using computer games for learning, demonstrated greater confidence in using computer games, and showed more enjoyment in the activities (Liu, Lee, & Chen, 2013). In the same vein, it was found that boys reported greater feelings of reward related to success in games (Hamlen, 2010). Such differences in attitudes and strategies may results in varied levels of creative performances.

As for gender differences in emotions, sociological research have consistently found that men report more frequent positive and less frequent negative feelings than women (Simon, 2014). Along the same line, it was found that girls experienced more anxiety and greater difficulties regulating their negative emotions than boys, suggesting that females have greater non-acceptance of negative emotions and less access to effective emotion regulation strategies than boys (Bender, Reinholdt-Dunne, Esbjørn, & Pons, 2012). On the contrary, it was found that females were more likely to use emotion regulation strategies than males (Zhao et al., 2014). Such inconsistent findings of gender differences bring about an interesting question: Are there gender differences with regard to how emotions influence game-based creativity?

2. The present study

As aforementioned, researchers have seldom focused on the role of emotions in game-based learning, especially negative emotions. In studies investigating positive emotions, most have focused on enjoyment and the flow experience. To date, no studies have examined the relationship between the three dimensions of emotions (valence, arousal, and regulation focus) and creativity in games. However, a recent study (Yeh, 2012) found that highly activated positive emotions with a promotion focus facilitated creativity and that highly activated negative emotions with a promotion focus hindered creativity. Moreover, games are interactive, and strong emotions usually occur during the game, especially when players are aware of the difficulties of challenges (Baldaro et al., 2004; Faiola et al., 2012). Thus, player's emotions may change and dynamically influence their creativity during the game playing process based on the challenges they perceive. On the other hand, although gender differences may exist in game-based creativity and emotions, and therefore, bring about different interaction patterns, the robust predictive power of emotions on creativity found in past studies seem to favor the argument that the dynamic influence patterns between emotions and game-based creativity should be similar across genders. Accordingly, this study used college students as participants and aimed to explore how different types of emotion before and during the game influenced their creativity; meanwhile, gender differences were examined in an exploratory manner. The following hypotheses were proposed in this study:

H1. Positive emotions during the game, particularly emotions with a high level of activation and a regulation focus of promotion, positively predict both male and female college students' performance on game-based creativity.

H2. Negative emotions during the game, particularly emotions with a high level of activation and a regulation focus of promotion, negatively predict both male and female college students' performance on game-based creativity.

3. Methods

3.1. Participants

All experimental tasks and data collection were conducted via a computer system. Two hundred and sixty-six undergraduates (77 males and 189 females) participated in this study. The participants' mean age was 19.94 years ($SD = 2.498$ years). All participants filled out an informed consent form before the experiment and received approximately $10 USD for participation.

3.2. Instruments

3.2.1. The framework and the characteristics of the CGES

The main instrument employed in this study was the *Creativity Game-based Evaluation System (CGES)*. In this study, the CGES was developed to evaluate game-based creativity using web techniques, multi-agent systems, and a rule-based agent system. It was composed of three agents: the User Interface Agent which was employed to collect personal information, the Creativity Game

Agent which was employed to evaluate creativity, and the Questionnaire Agent which was used to measure emotions (see Fig. 1). The main characteristics of the CGES included great convenience and portability, efficient evaluation, and cross-domain integration (see Table 1).

3.2.2. Creativity game agent

The CGES included a series of insight problem tasks that were adapted from the Situation-based Creativity Tasks (SCT) to evaluate the participants' game-based creativity in this study. The SCT was developed by Flash. The original SCT included three situation- and game-based insight problem scenarios which have been successfully employed to measure creativity (Lin, Yeh, Hung, & Chang, 2013; Yeh, Lai, Lin, Lin, & Sun, 2015).

It has been suggested that creativity is sparked when players engage in the process of problem solving and that digital games result in the exploration of different combinations and abilities to solve problems in creative ways (Hsiao, Chang, Lin, & Hu, 2014). Based on past findings with regard to effective game design and flow experiences (Chang et al., 2012; Faiola et al., 2012; Hsiao et al., 2014; Kiili, 2005; Niederhauser & Stoddart, 2001), the creativity games employed in this study included the following characteristics: (1) solving complex problems in a structured context, in which tools were provided to assist players to solve problems; (2) containing clear goals and specific feedback; (3) containing appropriate challenges and autonomy to enhance positive emotions; and (4) enhancing attention and immersion to increase concentration level and emotional arousal. Specifically, the goal of the SCT was to escape from the living room, the kitchen, and the bathroom. Each scenario of the SCT consisted of 10 insight problems, and the problems could be solved with different paths. In this study, only the living room and the kitchen game scenarios were included in the Creativity Game Agent due to time constraints. In each of the game scenarios, two instruments provided in the situation had to be correctly combined in order to solve each of the problems (see Fig. 2 for the example of problem solving). Immediate feedback was given with regard to whether the answer was right or wrong. Correct answers would be also shown on the right column so that the participant could know the progress of problem solving. In these games, an incorrect answer received 0 points and a correct answer received 1 point. The highest total score was 20 points (10 points in each game scenario). The time limit of 10 min for each of the game scenario and a count-down clock were set to enhance attention and immersion.

3.2.3. The questionnaire agent

The aim of the Questionnaire Agent was to collect data on the participants' emotions. In this study, the Inventory of Three-dimensional Emotions (I3E) was employed to measure the participants' emotions in this study (Yeh, Lin, Yeh, & Lin, 2012). The I3E included three dimensions: valence (positive vs. negative), activation (high vs. low), and regulatory focus (prevention vs. promotion). The I3E was composed of 8 types of emotions, each of which included 2 items (see Table 2). Each item was scored from 1 to 4 points, representing “highly disagree” to “highly agree”. A confirmatory factor analysis (CFA) indicated that both the negative emotion model and the positive emotion model have good construct validity; moreover, Cronbach's α for the I3E is .839 (Yeh et al., 2012). Based on the nature of our games, the following four types of emotions were more related and therefore were employed in this study: the positive-low activation-prevention emotion (P-L-Pre) (calm and relaxed), the positive-high activation-promotion emotion (P-H-Pro) (happy and elated), the negative-high activation-prevention emotion (N-H-Pre) (nervous and anxious), and the negative-high activation-promotion emotion (N-H-Pro) (frustrated and angry). Based on the data of this study, the Cronbach's α for the four types of emotions were .84, .76, .66, and .82.

3.3. Procedures

This study used desktop computers to collect data. All study procedures were approved by the University's Institutional Review Board (IRB). To increase validity and reliability, the data were collected individually in the laboratory. It took approximately

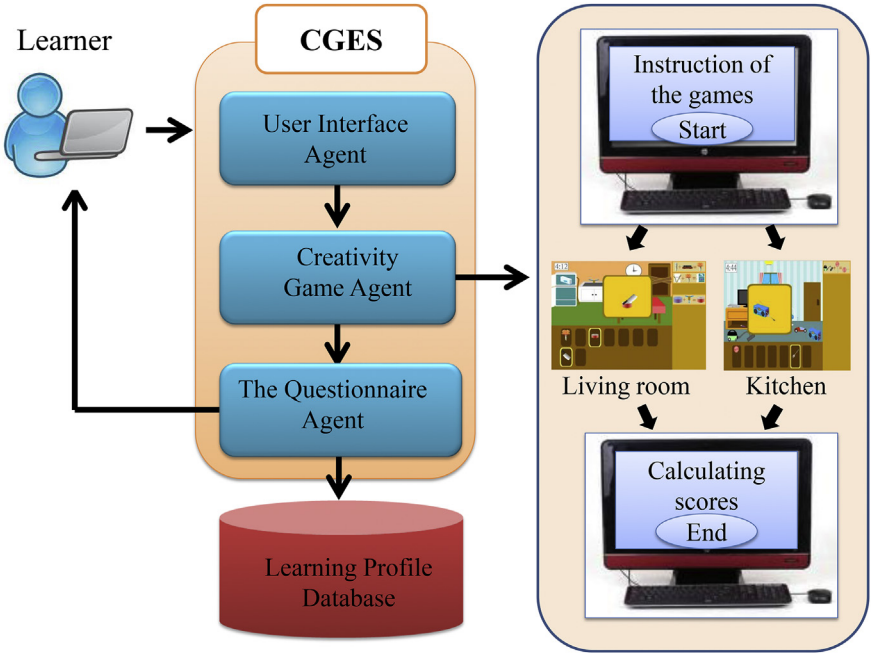

Fig. 1. The structure of the CGES.

Table 1
The characteristics of the CGES.

Convenience and portability
• The CGES was developed based on web techniques; thus, learning materials are not constrained by locations. Learners can learn anywhere on web-based learning systems.
• The CGES was developed via PHP, Net, and JavaScript, which makes the system adaptable to mobile devices (e.g., smart phones and electronic pads).
Efficient evaluation
• Multi-agents were employed to modulate the learning environment with different types of agents, which enabled different routes to solve problems.
• Learning performance was efficiently evaluated through multi-agents based on the Web framework.
Cross-domain integration
• The theories of creativity and cognitive psychology were employed as the theoretical bases of the CGES.
• The animation technology and the techniques of knowledge management were used to support the game-based environment.

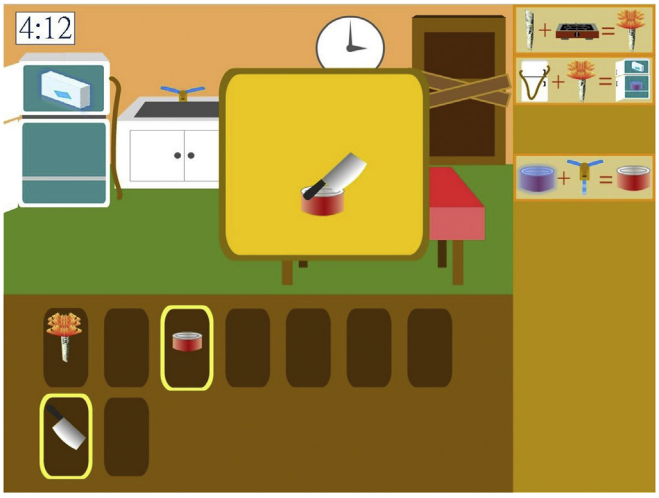

Fig. 2. An example screen in the game.

40 min. The experimental procedures were as follows:

- Step 1: The learner registered personal information with the User Interface Agent.
- Step 2: An instruction screen was displayed after the system verified the identity of the user. To ensure that the learner completely understood the procedures for how to complete the tasks in the CGES, as well as to increase the reliability and validity of the collected data, an instruction subsystem was designed in the CGES.
- Step 3: The Questionnaire Agent collected the baseline data of emotions (Time 1).
- Step 4: The Creativity Game Agent prompted the learner to solve problems in the Living room game scenario.
- Step 5: The Questionnaire Agent collected the data of emotions during game playing (Time 2).
- Step 6: The Creativity Game Agent prompted the learner to solve problems in the kitchen game scenario.
- Step 7: The learner received a debriefing.

4. Results

4.1. Preliminary analysis

Preliminary analysis showed that there was a gender difference in performance on creativity games, $F(1, 264) = 4.997$, $p = .026$, $\eta^2_p = .019$; specifically, the males outperformed the females ($M = 9.27$ vs. 7.59). On the other hand, no gender differences were found on the four types of emotions with regard to the changes between Time 1 (before the games) and Time 2 (during the games), $F(1, 264) = .181$, 3.541, .442, and 1.324 ($ps > .05$) for P-L-Pre (calm and relaxed), P-H-Pro (happy and elated), N-H-Pre (nervous and anxious), and N-H-Pro (frustrated and angry), respectively. To clearly depict the dynamic relationship between emotion and creativity, we conducted the following analyses with each gender.

4.2. The effect of emotions on creativity

To examine whether there were dynamic interactions between emotions (P-L-Pre, P-H-Pro, N-H-Pre, N-H-Pro) and creativity in games, we used the Time 1 emotion as the baseline and used the Time 2 emotion as the comparison line to examine how emotions influence game-based creativity at different time points. The means and standard deviations of males and females are shown in Fig. 3 (a) and Fig. 3 (b).

4.2.1. Positive emotions and game-based creativity

Regression analyses showed that the positive emotions at Time 1 (P-L-Pre_{T1} and P-H-Pro_{T1}) could not collectively predict either the male or the female participants' creativity, $Rs = .244$ and .242, $ps > .05$. However, the positive emotions at Time 2 (P-L-Pre_{T2} and P-H-Pro_{T2}) could collectively predict both the male and the female participants' creativity, $Rs = .606$ and .350, $ps = .000$, respectively (see Table 3).

T-tests of βs found that the positive emotion of P-L-Pre_{T1} (calm, relaxed) before the game could predict the female participants' creativity, $t = 3.347$, $p = .001$. Moreover, the positive emotion of P-H-Pro_{T2} (happy and elated) during the game powerfully predicted both the male and the female participants' creativity, $ts = 6.553$ and 4.995, $ps = .000$ (see Table 4).

Table 2
The construct of the I3E.

Positive				Negative			
Low-activation		High-activation		Low-activation		High-activation	
Prevention focused	Promotion focused	Prevention focused	Promotion focused	Prevention focused	Promotion focused	Prevention focused	Promotion focused
Calm	Warm	Secure	Happy	Isolated	Sad	Tense	Angry
Relaxed	Lively	Trusting	Elated	Exhausted	Disappointed	Fear	Frustrated

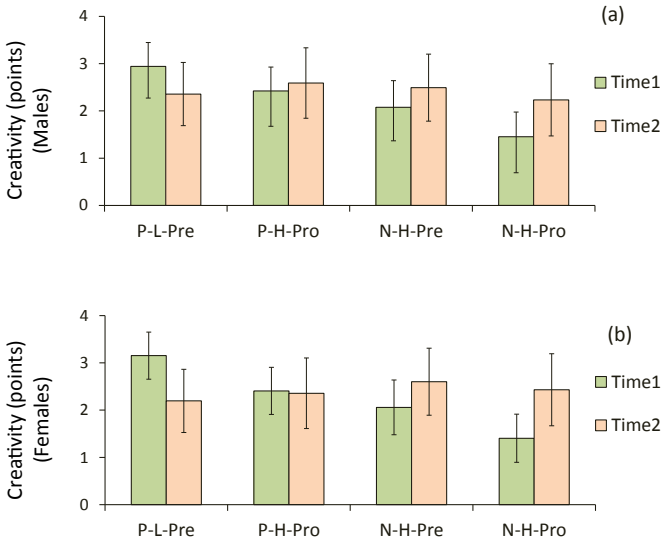

Fig. 3. The means and standard deviations of male and female creativity in different emotion groups. *Note*. P-L-Pre: Positive-Low activation-Prevention (calm and relaxed). P-H-Pro: Positive-High activation-Promotion (happy and elated). N-H-Pre: Negative-High activation-Prevention (nervous and anxious). N-H-Pro: Negative-High activation-Promotion (angry and frustrated).

Table 3
Model summary for predicting creativity via positive emotions at Time 1 and Time 2.

Gender	*R*	R^2	Adjusted R^2	Change statistics			
				F change	*df*1	*df*2	Sig. *F* change
Time 1							
Male	.173	.030	.004	1.297	2	74	.279
Female	.242	.059	.049	1.286	2	186	.279
Time 2							
Male	.606	.367	.350	21.471***	2	74	.000
Female	.350	.123	.113	12.995***	2	186	.000

***$p < .001$.

4.2.2. Negative emotions and game-based creativity

Regression analyses showed that the negative emotions at Time 1 (N-H-Pre_{T1} and N-H-Pro_{T1}) could not predict either the male or the female participants' creativity, *Rs* = .184 and .117, *ps* > .05.

Table 5
Model summary for predicting creativity via negative emotions at Time 1 and Time 2.

Gender	*R*	R^2	Adjusted R^2	Change statistics			
				F change	*df*1	*df*2	Sig. *F* change
Time 1							
Male	.184	.034	.008	1.297	2	74	.279
Female	.117	.014	.003	1.286	2	186	.279
Time 2							
Male	.459	.210	.189	9.862***	2	74	.000
Female	.316	.100	.090	10.319***	2	186	.000

***$p < .001$.

However, the negative emotions at Time 2 (N-H-Pre_{T2} and N-H-Pro_{T2}) could collectively predict both the male and the female participants' creativity, *Rs* = .459 and .316, *ps* = .000 (see Table 5).

T-tests of βs found that the negative emotion of N-H-Pro_{T2} (angry and frustrated) during the game powerfully predicted both the male and the female participants' creativity, *ts* = −4.066 and −4.268, *ps* = .000 (see Table 6).

5. Discussion

Preliminary analysis showed that the males outperformed the females on game-based creativity. This finding is not consistent with previous findings that indicated females' performance on creativity measures is better than males (Baer & Kaufman, 2008; Naderi et al., 2009) and that games may have positive effects on engaging learning experiences for female players (Dickey, 2006). However, the results here lend support to the findings that the neurophysiological mechanisms of creativity are different in men and women (Volf & Tarasova, 2013) and that males have better performance on insight problem solving tasks (Lin et al., 2012); the creativity tasks employed in this study are, in essence, insight problem-solving tasks. In studies of games, researchers have found that males spend more time in playing video (Homer et al., 2012), derive more enjoyment from the computer games (Liu et al., 2013), and get more success-related rewards in games than females (Hamlen, 2010), which contribute to their better performance than females within digital games. Moreover, strategies employed during gaming also help interpreting gender differences in the creative performance (Abraham, 2015). It has been found that male students

Table 4
Coefficients of regression analysis for predicting creativity via positive emotions at Time 1 and Time 2.

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	β	*t*	Sig.
Time 1					
Male					
(Constant)	4.827	5.313		.908	.367
P-L-Pre_{T1}	−.067	1.295	−.006	−.052	.959
P−H-Pro_{T1}	1.917	1.293	.172	1.482	.143
Female					
(Constant)	1.953	2.826		.691	.490
P-L-Pre_{T1}	2.759	.825	.248	3.347***	.001
P−H-Pro_{T1}	−1.274	.824	−.115	−1.547	.124
Time 2					
Male					
(Constant)	.565	2.341		.241	.810
P-L-Pre_{T2}	−1.587	.819	−.187	−1.937	.057
P−H-Pro_{T2}	4.805	.733	.633	6.553***	.000
Female					
(Constant)	2.478	1.514		1.637	.103
P-L-Pre_{T2}	−.579	.614	−.070	−.943	.347
P-H-Pro_{T2}	2.707	.542	.371	4.995***	.000

***$p < .001$.

Table 6
Coefficients of regression analysis for predicting creativity via negative emotions at Time 1 and Time 2.

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	β	*t*	Sig.
Time 1					
Male					
(Constant)	6.962	2.724		2.556*	.013
N-H-Pre$_{T1}$	1.888	1.209	.187	1.562	.122
N-H-Pro$_{T1}$	−1.109	1.306	−.102	−.849	.398
Female					
(Constant)	9.496	1.637		5.803***	.000
N-H-Pre$_{T1}$	−1.177	.735	−.123	−1.601	.111
N-H-Pro$_{T1}$	.365	.837	.034	.436	.663
Time 2					
Male					
(Constant)	15.492	2.227		6.956***	.000
N-H-Pre$_{T2}$	.952	1.018	.119	.935	.353
N-H-Pro$_{T2}$	−3.846	.946	−.518	−4.066***	.000
Female					
(Constant)	12.332	1.692		7.288***	.000
N-H-Pre$_{T2}$	.575	.694	.067	.828	.409
N-H-Pro$_{T2}$	−2.567	.601	−.345	−4.268***	.000

*** $p < .001$.

are more likely to embrace a manipulation-oriented information processing approach, a command strategy for executing tasks, and a competitive social comportment when using computer games. Such strategies may help males to get high scores in games (Liu et al., 2013). On the other hand, the insignificant gender differences in emotion changes suggest that the male and female college students do not differ in experiencing the emotions and using emotion regulation strategies during the game playing, which are not consistent with past findings (Bender et al., 2012; Zhao et al., 2014).

In this study, we did regression analyses separately based on the male and female samples. The findings suggest that although there is a slight gender difference in game-based creativity, the prediction power and pattern of emotions in game-based creativity are very similar among participants with different genders. Specifically, emotions with a high activation level and a promotion focus during the game can predict performance on game-based creativity across genders; however, the influence direction is opposite with regards to emotional valence (positive emotions vs. negative emotions). In other words, while the positive-high activation-promotion emotions (happy and elated) during the game facilitate creativity, the negative-high activation-promotion emotions (angry and frustrated) hinder creativity. The r^2 values also suggest that the prediction power of the positive-high activation-promotion emotions are greater than those of the negative-high activation-promotion emotions. These findings support our hypotheses that emotions during the game, particularly the emotions with a high level of activation and a regulation focus of promotion, can predict college students' performance on game-based creativity. The results support that the three-dimensional theory of emotion (Baas et al., 2008) can depict the complex relationship between emotions and creativity, as well as that a positive emotional state facilitates creativity as it enhances cognitive flexibility and the association network (Baas et al., 2008; Davis, 2009; Forgeard, 2011; Hutton & Sundar, 2010; Subramaniam et al., 2009). Moreover, the findings are in line with the social cognitive perspective of self-regulation learning and suggest that positive self-reactions are self-initiated, social, and motivational as well as such processes facilitate task interest, task choice, and persistence (Zimmerman, 2011). In addition, the results lend support to the findings that flow experience and enjoyment can facilitate creativity (Boyle et al., 2011; Chang et al., 2012) and highly activated emotions lead to more creativity than do deactivating emotions (De Dreu et al., 2008). Accordingly, the CGES developed in this study can serve as an effective evaluation system for creativity and its underlying mechanisms can enhance the flow experiences and, further facilitate creativity.

The findings in this study also illustrate the dynamic influence of emotions on game-based creativity, which lends support to our hypothesis. Specifically, we found that the overall baseline emotion did not have a significant influence on subsequent creativity in games. However, as the game progresses, all participants' negative emotions, especially those with a high activation-promotion focus (angry and frustration), increased gradually. On the other hand, the influence of positive emotions, especially those with a high activation-promotion focus (happy and elated), on game-based creativity also increased to a significant level. These findings suggest that there are dynamic interactions between the players and the game. Moreover, the increase of highly-activated and promotion-focused negative emotions indicates that great challenges have been provided in the creativity games. What's more, the increasing influences of highly-activated and promotion-focused positive emotions on creativity suggests that when challenges can be overcome, positive emotions can be induced, which further enhances the player's creativity performance. These findings are in line with the claims that challenges can foster creativity and proactive actions (Baer & Oldham, 2006; Kangas, 2010; Ohly & Fritz, 2010). In games, players are required to overcome the challenges provided through generating solutions in the ideation loop. “Win” experiences is a critical process that keeps players engaged and moving forward in a game (Starks, 2014). According to the Geneplore model (Ward, Smith, & Finke, 1999), creative activities can be described as an initial generation of candidate ideas or solutions followed by extensive exploration of those ideas. Therefore, players' creativity can be enhanced by overcoming the challenges in games (Kiili, 2005) and the “win” experiences. This study also suggests that when the challenges cannot be conquered, highly activated negative emotions with a promotion focus can be induced, which may further hinder creativity performance. A previous study (Hirt et al., 2008) suggests that negative emotions motivate actions to solve problems. In contrast, the current findings suggest that the perceived feeling of negative emotions may decrease self-confidence and further hinder creativity. Thus, in a game-based creativity evaluation system, it is very important to provide appropriate challenges to increase highly-activated and

promotion-focused positive emotions.

6. Conclusions, limitations, and suggestions

As games are commonly played among the young generation in developed countries, it is important to determine how to transform strong learning motivation and passion in games into educational resources. Because creativity is one of the most important abilities to succeed in our technological and changing society, this study developed a game-based evaluation system for college students and investigated from an integrated perspective to explore how different types of emotions may influence creativity during game playing. The findings in this study provide important insights and implications for games designed to evaluate or improve creativity. The main findings in this study suggest that the influence of emotions on game-based creativity is dynamic; more specifically, emotions during game playing can better predict creativity than those of the baseline. Moreover, highly-activated positive emotions with a promotion focus can facilitate creativity performance, whereas highly-activated negative emotions with a promotion focus can decrease creativity performance. Accordingly, providing appropriate challenges to induce such positive emotions, as well to decrease such negative emotions, are critical for the success of games designed to improve creativity. To achieve this goal, complex problem solving, clear goal setting, immediate and specific feedback, autonomous decision making for problem solving, appropriate challenges for emotional arousal, win and flow experiences, and sense of immersion, should be considered simultaneously.

In this study, emotions were not manipulated. Further studies should aim to induce different types of emotions during game playing and investigate whether the dynamic interaction between emotions and creativity may differ across the manipulations. Moreover, the threshold of challenges may differ among players; future studies can design games for evaluating individual differences and design a personalized game-based learning system for improving learners' creativity.

Moreover, it was found that males favored the massively multiplayer online role-play games and females preferred party games (Procci, James, & Bowers, 2013). It was also found that males had greater confidence in controlling computer games and when playing a new game or a difficult game, females required more task-related supports to build competence and confidence (Liu et al., 2013). This study did not include different types of games, nor provide extra supports to the female participants. Further studies can consider these components when designing games for improving creativity.

Finally, for students to become creative, teachers should be able to provide a culture that values creativity (Craft, 2005). Game-based learning provides challenging experiences that enhance learners' intrinsic motivation and offer opportunities for authentic learning (Frossard, Barajas, & Trifonova, 2012). Teachers are encouraged to collaboratively design their own game-based learning scenarios, especially those tailored to their teaching contexts and student needs.

Acknowledgments

This work was supported by the Ministry of Science and Technology in Taiwan under Grants NSC 100-2511-S-004-002-MY3 and NSC 101-2420-H-004-014-MY2. We thank Chun Fu Lin and Yu Hsin Hung for helping data collection.

References

Abraham, A. (2015). Gender and creativity: an overview of psychological and neuroscientific literature. *Brain Imaging and Behavior*. http://dx.doi.org/10.1007/s11682-015-9410-8.

Abraham, A., & Windmann, S. (2007). Creative cognition: the diverse operations and the prospect of applying a cognitive neuroscience perspective. *Methods, 42*(1), 38–48.

Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: hedonic tone, activation, or regulatory focus? *Psychological Bulletin, 134*(6), 779–806.

Baer, J., & Kaufman, J. C. (2008). Gender differences in creativity. *The Journal of Creative Behavior, 42*(2), 75–105.

Baer, M., & Oldham, G. R. (2006). The curvilinear relation between experienced creative time pressure and creativity: moderating effects of openness to experience and support for creativity. *Journal of Applied Psychology, 91*, 963–970.

Baldaro, B., Tuozzi, G., Codispoti, M., Montebarocci, O., Barbagli, F., Trombini, E., et al. (2004). Aggressive and non-violent videogames: short-term psychological and cardiovascular effects on habitual players. *Stress and Health, 20*(4), 203–208.

Baruch, R., Grotberg, E. H., & Stutman, S. (2008). *Creative anger: Putting that powerful emotion to good use*. Westport, CT: Praeger Publishers.

Bayliss, J. D. (2007). The effects of games in CS1-3. In *Proceedings of Microsoft academic days conference on game development in computer science education, 2007* (pp. 59–63).

Bender, P. K., Reinholdt-Dunne, M. L., Esbjørn, B. H., & Pons, F. (2012). Emotion dysregulation and anxiety in children and adolescents: gender differences. *Personality and Individual Differences, 53*(3), 284–288.

Boyle, E., Connolly, T. M., & Hainey, T. (2011). The role of psychology in understanding the impact of computer games. *Entertainment Computing, 2*(2), 69–74.

Byron, K., Khazanchi, S., & Nazarian, D. (2010). The relationship between stressors and creativity: a meta-analysis examining competing theoretical models. *Journal of Applied Psychology, 95*(1), 201–212.

Carlsson, I. (2002). Anxiety and flexibility of defense related to high or low creativity. *Creativity Research Journal, 14*(3–4), 341–349.

Chang, K. E., Wu, L. J., Weng, S. E., & Sung, Y. T. (2012). Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers & Education, 58*(2), 775–786.

Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education, 55*(4), 1618–1627.

Craft, A. (2005). *Creativity in schools: Tensions and dilemmas*. London: Routledge.

Davis, M. A. (2009). Understanding the relationship between mood and creativity: a meta-analysis. *Organizational behavior and human decision processes, 108*(1), 25–38.

De Dreu, C. K., Baas, M., & Nijstad, B. A. (2008). Hedonic tone and activation level in the mood-creativity link: toward a dual pathway to creativity model. *Journal of Personality and Social Psychology, 94*(5), 739–756.

Dickey, M. D. (2006). Girl gamers: the controversy of girl games and the relevance of female-oriented game design for instructional design. *British journal of educational technology, 37*(5), 785–793.

Dickey, M. D. (2011). Murder on Grimm Isle: the impact of game narrative design in an educational game-based learning environment. *British Journal of Educational Technology, 42*(3), 456–469.

Dineen, R., Samuel, E., & Livesey, K. (2005). The promotion of creativity in learners: theory and practice. *Art, Design & Communication in Higher Education, 4*(3), 155–172.

Faiola, A., Newlon, C., Pfaff, M., & Smyslova, O. (2012). Correlating the effects of flow and telepresence in virtual worlds: enhancing our understanding of user behavior in game-based learning. *Computers in Human Behavior, 29*(3), 1113–1127.

Fong, C. T. (2006). The effects of emotional ambivalence on creativity. *Academy of Management Journal, 49*(5), 1016–1030.

Forgeard, M. J. C. (2011). Happy people thrive on adversity: pre-existing mood moderates the effect of emotion inductions on creative thinking. *Personality and Individual Differences, 51*(8), 904–909.

Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social Psychology, 95*(5), 1045–1062.

Freitas, S. D., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers and Education, 46*, 249–264.

Frossard, F., Barajas, M., & Trifonova, A. (2012). A learner-centred game-design approach: impacts on teachers' creativity. *Digital Education Review, 21*, 13–22.

Fu, F. L., Su, R. C., & Yu, S. C. (2009). EGameFlow: a scale to measure learners' enjoyment of e-learning games. *Computers & Education, 52*(1), 101–112.

Gentile, D. A., & Gentile, J. R. (2008). Violent video games as exemplary teachers: a conceptual analysis. *Journal of Youth and Adolescence, 37*(2), 127–141.

Hamlen, K. R. (2010). Re-examining gender differences in video game play: time spent and feelings of success. *Journal of Educational Computing Research, 43*(3), 293–308.

Hennessey, B. A., & Amabile, T. M. (2010). Creativity. *Annual Review of Psychology, 61*(1), 569–598.

Hirt, E. R., Devers, E. E., & McCrea, S. M. (2008). I want to be creative: exploring the role of hedonic contingency theory in the positive mood-cognitive flexibility link. *Journal of Personality and Social Psychology, 94*(2), 214–230.

Homer, B. D., Hayward, E. O., Frye, J., & Plass, J. L. (2012). Gender and player

characteristics in video game play of preadolescents. *Computers in Human Behavior, 28*(5), 1782–1789.
Hsiao, H.-S., Chang, C.-S., Lin, C.-Y., & Hu, P.-M. (2014). Development of children's creativity and manual skills within digital game-based learning environment. *Journal of Computer Assisted Learning, 30*(4), 377–395.
Hung, P. H., Hwang, G. J., Lee, Y. H., & Su, I. (2012). A cognitive component analysis approach for developing game-based spatial learning tools. *Computers & Education, 59*(2), 762–773.
Hutton, E., & Sundar, S. S. (2010). Can video games enhance creativity? effects of emotion generated by dance dance revolution. *Creativity Research Journal, 22*(3), 294–303.
Isbister, K. (2011). Emotion and motion: games as inspiration for shaping the future of interface. *Interactions, 18*(5), 24–27. C.
Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., et al. (2008). Measuring and defining the experience of immersion in games. *International Journal of Human-computer Studies, 66*(9), 641–661.
Jones, E. E., & Kelly, J. R. (2009). No pain, no gains: negative mood leads to process gains in idea-generation groups. *Group Dynamics: Theory, Research, and Practice, 13*(2), 75–88.
Kampylis, P., Berki, E., & Saariluoma, P. (2009). In-service and prospective teachers' conceptions of creativity. *Thinking Skills and Creativity, 4*(1), 15–29.
Kangas, M. (2010). Creative and playful learning: learning through game co-creation and games in a playful learning environment. *Thinking Skills and Creativity, 5*(1), 1–15.
Kaufmann, G., & Vosburg, S. (1997). "Paradoxical" mood effects on creative problem-solving. *Cognition and Emotion, 11*(2), 151–170.
Kiili, K. (2005). Digital game-based learning: towards an experiential gaming model. *The Internet and higher education, 8*(1), 13–24.
Kinzie, M. B., & Joseph, D. R. D. (2008). Gender differences in game activity preferences of middle school children: implications for educational game design. *Education Technology Research and Development, 56*, 643–663.
Lenga, E. Y., Alib, W. Z. W., Mahmudb, R., & Baki, R. (2010). Computer games development experience and appreciative learning approach for creative process enhancement. *Computers & Education, 55*(3), 1131–1144.
Lin, W.-L., Hsu, K.-Y., Chen, H.-C., & Wang, J.-W. (2012). The relations of gender and personality traits on different creativities: a dual-process theory account. *Psychology of Aesthetics, Creativity, and the Arts, 6*(2), 112–123.
Lin, C. F., Yeh, Y., Hung, Y. H., & Chang, R. I. (2013). Data mining for providing a personalized learning path in creativity: an application of decision trees. *Computers & Education, 66*, 199–210.
Liu, E. Z.-F., Lee, C.-Y., & Chen, J.-H. (2013). Developing a new computer game attitude scale for Taiwanese early adolescents. *Educational Technology & Society, 16*(1), 183–193.
MacDonald, C. J., Stodel, E. J., Farres, L. G., Breithaupt, K., & Gabriel, M. A. (2001). The demand-driveb learning model: a framework for web-based learning. *Internet and Higher Education, 4*, 9–30.
Michalewicz, Z., & Michalewicz, M. (2007). Puzzle-based learning. In *Proceedings of the 18th conference of the Australasian association for engineering education, 2007* (pp. 1–8).
Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London: Learning And Skills Development Agency.
Naderi, H., Abdullah, R., Aizan, H. T., Sharir, J., & Kumar, V. (2009). Creativity, age and gender as predictors of academic achievement among undergraduate students. *Journal of American Science, 5*(5), 101–112.
Niederhauser, D. S., & Stoddart, T. (2001). Teachers' instructional perspectives and use of educational software. *Teaching and Teacher Education, 17*, 15–31.
Ohly, S., & Fritz, C. (2010). Work characteristics, challenge appraisal, creativity, and proactive behavior: a multi-level study. *Journal of Organizational Behavior, 31*(4), 543–565.
Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment, 1*(1), 21–21.
Procci, K., James, N., & Bowers, C. (2013). The effects of gender, age, and experience on game engagement. In *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 57(1), pp. 2132–2136).
Runco, M. A., Cramond, B., & Pagnani, A. R. (2010). Gender and creativity. In J. C. Chrisler, & D. R. McCreary (Eds.), *Handbook of gender research in psychology* (pp. 343–357). New York: Springer. Retrieved from http://www.springerlink.com/content/r193k8872152l51k/abstract/.
Simon, R. W. (2014). Sociological scholarship on gender differences in emotion and emotional well-being in the United States: a snapshot of the field. *Emotion Review, 6*(3), 196–201.
Starks, K. (2014). Cognitive behavioral game design: a unified model for designing serious games. *Journal of Frontiers in Psychology, 5*(28), 1–10.
Subramaniam, K., Kounios, J., Parrish, T. B., & Jung-Beeman, M. (2009). A brain mechanism for facilitation of insight by positive affect. *Journal of Cognitive Neuroscience, 21*, 415–432.
Sung, H. Y., & Hwang, G. J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education, 63*, 43–51.
Tolegenova, A. A., Kustubayeva, A. M., & Matthews, G. (2014). Trait meta-mood, gender and EEG response during emotion-regulation. *Personality and Individual Differences, 65*, 75–80.
Volf, N. V., & Tarasova, I. B. (2013). The influence of reward on the performance of verbal creative tasks: behavioral and EEG effects. *Human Physiology, 39*(3), 302–308.
Ward, T. B., Smith, S. M., & Finke, R. A. (1999). Creative cognition. In R. Sternberg (Ed.), *Handbook of creativity*. New York: NY, Cambridge University.
Yang, J. C., & Chen, S. Y. (2010). Effects of gender differences and spatial abilities within a digital pentominoes game. *Computers & Education, 55*(3), 1220–1233.
Yeh, Y. (2011). Research and methods. In M. A. Runco, & S. R. Pritzker (Eds.) (2nd ed.,, *2. Encyclopedia of creativity* (pp. 291–298). San Diego, CA: Academic Press.
Yeh, Y. (2012). *Deconstructing and reconstructing the cognitive process of creativity via digital games (NSC 100-2511-S-004 -002 -MY3)*. Taipei: The National Science Council of the Republic of China in Taiwan.
Yeh, Y., Lai, G. J., Lin, C. F., Lin, C. W., & Sun, H. C. (2015). How stress influences creativity in game-based situations: analysis of stress hormone, negative emotions, and working memory. *Computers & Education, 81*, 143–153.
Yeh, Y., Lin, C. F., Yeh, Y. L., & Lin, C. W. (2012, October). The development of the inventory of three-dimensional emotions. In *Paper presented at the annual conference of Taiwanese psychological association, October, 14–16*. Taichung, Taiwan: Asia University.
Zenasni, F., & Lubart, T. I. (2008). Emotion-related traits moderate the impact of emotional state on creative performances. *Journal of Individual Differences, 29*(3), 157–167.
Zenasni, F., & Lubart, T. I. (2009). Perception of emotion, alexithymia and creative potential. *Personality and Individual Differences, 46*(3), 353–358.
Zeng, L., Proctor, R. W., & Salvendy, G. (2011). Can traditional divergent thinking tests be trusted in measuring and predicting real-world creativity? *Creativity Research Journal, 23*(1), 24–37.
Zhao, X., Zhang, R., & Zheng, K. (2014). Gender differences in emotion regulation strategies in adolescents. *Chinese Journal of Clinical Psychology, 22*, 849–854.
Zimmerman, B. J. (2011). Motivational sources and outcomes of self-regulated learning and performance. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 49–64). New York, NY: Routledge.
Zin, G., Escobal, G., Esteves, G., & Goyos, C. (2015). Sharing game: influence of gender, cost of response, history of reinforcement, and amount of money in the resource distribution of undergraduate students. *Behavior Analysis: Research and Practice, 15*(1), 65–80.