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Design principles for improving emotional affordances in an online learning environment

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Abstract

This study aims to develop and validate essential design principles for improving emotional affordances in an online learning environment by investigating theoretical and practical mechanisms of integrating emotions into the instructional design and technology. To achieve this goal, we applied design and development research methodology in accordance with the procedure of development by reviewing relevant extant literature and then performing validation through a three-round expert review and usability evaluation. For the first stage of development, ten design principles were derived after synthesizing and elaborating related variables through a literature review. For the next stage of validation, eight experts were asked to review these principles, and three instructional designers participated in testing the usability. The findings suggest that online learning environments should reflect the eight design principles of positivity, playfulness, humanity, self-disclosure, safety, personalization, affinity, and intimacy for enhancing visceral, behavioral, and reflective emotional affordances with regard to learning activities, learning support, learner interface (LI)/learner eXperience (LX), and learning screen. We discuss the results and practical implications of the findings for future research.

Keywords Emotional affordances · Online learning environments · Design principles · Design and development research

Introduction

In an online learning environment, learners might feel lonely, anxious, bored, or frustrated (Järvelä et al. 2011; Wosnitza and Volet 2005; Zembylas et al. 2008). One possible explanation for this is that when students lack direct interactions with teachers and peers, they are likely to face emotional challenges (Artino and Jones 2012; Dabbagh and Kitsantas 2004; MacFadden et al. 2005; Whipp and Chiarelli 2004). Emotions are important contributors to learning, self-regulation, and academic achievement. They also have an influence on human judgment and behavior (Pekrun et al. 2002; Pekrun 2011). Studies emerging from neuroscience,

education, psychology, HCI, and affective computing have proven that emotions directly and indirectly affect students' learning by mediating their memory, attention, decision making, motivation, self-regulation/self-direction, social interaction, higher-order thinking and, lastly, creativity (D'Mello and Graesser 2012; LeDoux 1998; Norman 2004; Pekrun et al. 2002). Particularly, research on neuroscience reveals that the emotional brain and the cognitive brain are linked to each other in that a person cannot memorize, reason, judge, learn, and act without a working emotional brain; thus, an integrated view of emotion and cognition is needed. (LeDoux 1998; Sparrow and Knight 2006).

The distance education theory of Holmberg (1989, 2003) illustrates the role of course providers and instructors in inducing a sense of belonging and empathy. Thus, an online learning environment should be designed in such a way that induces learners' positive feelings and furthermore decrease their negative emotions. A growing body of research has demonstrated that emotions felt during online learning can enhance as well as hinder the learning process (Järvelä et al. 2011; Juutinen and Saariluoma 2010; Zembylas et al. 2008). When learners have emotional competence, they face the challenge of having continued motivation to learn especially

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in an online learning environment. According to MacFadden et al. (2005), the importance of learners' experiences of emotions has not been fully considered in the literature. Yet, there is little information on how we can integrate emotions in the design of instruction.

In this contemporary society of information, high-tech and high-touch artifacts which hide the coldness of digital technology with warm analog emotions have taken the spotlight (Pink 2006). Emotional competence and technological literacy are critical skills for the twenty-first century (WEF 2015). Emotional intelligence suggested by Salovey et al. (1995) does not entail the important role of the self and context in an individual's emotional skills. However, emotional competence is the individual's efficacy and motivation for engaging in some emotion-evoking situations or contexts and the individual's values and beliefs to their emotional experiences. Emotional competence is a general term that refers to many kinds of emotion-related skills (Garner 2010). Currently, emotional competence has been defined as the ability to be aware of, use, manage one's emotional reactions in ways that are appropriate to the audience, contexts, and situations (Cole et al. 2004; Eisenberg and Spinrad 2004). An emotionally supportive online learning environment facilitates learning by inducing learners' emotional reactions (Pekrun et al. 2009).

As the significance of emotions is growing in education and technology (Prendinger and Ishizuka 2005), the necessity of designing an emotionally supportive or affordable online learning environment is critical. The increasing emphasis on emotions is found in widespread fields (Norman 2004). Nevertheless, there is a limited body of research that indicates essential principles to design and create an emotionally affordable online environment. Furthermore, information is also lacking on how an online learning environment affords learners' emotions. One reason for this knowledge gap is that theories related to emotional design are too abstract. Recently, the concept of emotional affordance (EA) has been introduced and applied to develop a variety of technological tools or environments including a Virtual Reality (VR)-based online learning environment (Park et al. 2012; Seif El-Nasr et al. 2011; Zhang 2008). EA facilitates students' learning (Morie et al. 2005) and emotional skills (Schutte et al. 2008) in an online setting. To enhance online learners' emotional competence and learning, it is important to adopt EA theories to design an emotionally supportive learning environment.

Little has been recognized about how online learning environments afford learners' emotions. The main reason for the lack of research on the emotional design of online learning sites, systems, or programs is that the theory of emotional design is too disorganized or abstract to be used in the design of an online learning environment. Recently, the concept and models of EA were introduced and applied

to a variety of technological tools or environments, including VR-based learning environments.

This study attempts to use emotional affordances to design an online learning environment to support learners' emotional competence. To address it, this study has applied EA theory to design and develop emotional affordable online learning environments. This article starts with a review of the theories relating to emotions in the fields of neuroscience, psychology, education, and computing that have been used to study the linkage between emotion and cognition. This review is meant to be comprehensive to synthesize the existing research findings and implications and include various theoretical frameworks and definitions. Then, a systematic summary of the empirical research on the relationships between emotional design aspects, namely, EAs and their effects in online learning environments are presented. Next, research on the development and validation of design principles for emotional affordances in online learning environments will be carried out. Thus, this study investigates the importance of emotions and the necessity of emotional affordances in online learning environments from the perspective of affordance. Ultimately, the primary purpose of this study is to construct and internally validate design principles for designing emotional affordances in an online learning environment. In view of such a research purpose, the following two research questions were proposed:

1. What are the design principles of EA in online learning environments?
2. How can design principles of EA in online learning environments be validated by experts and end-users (i.e., instructional designers)?

Theoretical background

Emotion in an online learning environment

The representative educational theories relating to emotions are "discrete emotion theories" and "componential models of emotions." While discrete emotion theories assume that facial expressions reflect basic emotions that are patterned by specific emotion-evoking conditions or programs (Izard 1991; Ekman 1994), componential models of emotions assume that facial expressions convey components of the emotion process differentiated by the outcomes of appraisal (Scherer 1993, 2009). More current theoretical perspectives have supported the view that emotions influence learners' achievement (Pekrun et al. 2002). Feedback for learning progress as well as success/failure experiences can affect learners' emotions (Pekrun et al. 2002). An emotional climate of online learning shapes learners' expectancies, attitudes, feelings, and behaviors while they are engaged in learning

(Wosnitza and Volet 2005). Moreover, emotions affect their experiences and learning (Reily et al. 2012). According to Cheng (2014), an online learning context like MOOCs, which is required to meet diverse needs of learners, should address individual differences in emotions occurring in the process of learning. However, the mass production of cognitive and social experiences of learners in an online learning environment may not synchronize with the personalized or emotional engagement. Therefore, online learning could affect their emotions negatively as well as positively. By reviewing the previous literature, we classified emotions that learners tend to feel during online learning into 'positive' and 'negative' ones as shown in Table 1.

A recent advancement in affective computing and neurobiology, online learning systems have started recognizing and responding to learners' feelings through its user interface (UI) or user eXperience (UX) (Hassenzahl and Tractinsky 2006; Zurloni et al. 2008). Instructional designers and online learning system developers must consider critical factors promoting positive emotions or reducing negative emotions among learners for learning and performance (Pekrun 2011).

Emotional affordance (EA)

Gibson (1979), one of the ecologists of visual perception, coined a word affordance as the link between perceived elements of the environment and the possibility of human actions. Park et al. (2008) defined affordance as a property of an object, animal, and environment that causes certain actions. According to Kirschner et al. (2004) and Norman (2002), the concept of affordance gives an alternative theoretical framework for designing and evaluating online learning systems. EA is sometimes found in physical spaces that engage learners with emotional experiences (Kytta 2003).

Thus, the value of affordances can be expanded from functional to emotional areas. Morie et al. (2005) mentioned that all affordances play triggering roles that could lead to a certain action (e.g., physical responses) or a certain reaction (e.g., emotional responses) among the users. Moreover, emotional outcomes of EA can be positive/negative and intended/unintended, in accordance with students' internal and contextual features (Cheng 2014). Through reviewing prior studies on the concepts and characteristics of EAs as shown in Table 2, EA can be a critical element of learning design processes given that they can ultimately motivate or distract learners during learning.

The crucial determinant for using motivational affordances for designing information and communication technology (ICT) is inducing desired emotions by initially exposing to ICT and inducing intended emotions by intensively interacting with ICT (Zhang 2008). Such emotional design factors, namely, EA can induce optimal flow experience (Kytta 2003). EA would refer to emotional components for designing and developing learning environments design that contribute to facilitating students' engagement and learning.

The functioning of EAs in online learning environments has been underlined by various empirical studies. Cheng (2014) reported that MOOC discussion boards induced different emotions of participants such as positive emotions, negative emotions, and non-achievement emotions according to their learning progress (beginning/middle/end). Research adopting EAs in designing online learning environments has shown that EAs may have a positive effect on learners' emotion and learning. For instance, Morie et al. (2005) observed that emotionally affordable virtual environments for military training influenced subjects' perception/arousal and behaviors as a result of analyzing their skin conductance response, heart rate, self-report, and questionnaire. Research by Chuah

Table 1 Emotions in online learning environments

Research	Positive emotions	Negative emotions
O'Regan (2003)	Enthusiasm/excitement, pride	Frustration, fear, anxiety, apprehension, shame/embarrassment
Rowe (2005)	Content, satisfaction, freedom, peacefulness, relief, compassion, trust, comfort, empathy, dignity, hope, confidence, joy/delight	Despair, sorrow, upset, overwhelm, resentment, scary, worry, isolation, anxiety, fear, frustration, distress
Rha and Sung (2005)	Pleasure, delightfulness, pride	Concern, disappointment, anger
Rodrigo and De Baker (2011)	Engaged concentration, delight	Boredom, confusion, frustration
Artino and Jones (2012)	Enjoyment	Boredom, frustration
Park et al. (2012)	Joy	Sadness, anger, fear, disgust
Astleitner (2000)	Sympathy, pleasure	Fear, envy, anger
Kort et al. (2001)	Awe, satisfaction, curiosity, hopefulness	Disappointment, puzzlement, confusion, frustration, discard, misconception
Breazeal and Brooks (2005)	Content, soothed, joy	Sorrow, unhappy, disgust, fear, anger
Glaser-Zikuda et al. (2005)	Well-being, enjoyment, satisfaction, interest	Anxiety, boredom

Table 2 Concepts and characteristics of EAs

Research	Concepts and characteristics of EAs	Specific design elements
Rha et al. (2013)	• Clues to induce a sensitivity reaction that is inherent in the environment surrounding the human or the information • Basic elements, operational elements, and hidden display in the specific sensibility of these elements	– Textured text, meaning the possibility of the image, the three-dimensional properties of the object
Park et al. (2012)	• Design attributes of the environment and the objects to be to induce the emotional reaction and behavior in the interaction of the environment and the object is to the user, clue, or information	– Emotion supporting tool
Gay (1992)	• Realistic, objectively warranted, and unvarying value judgements that "pertain to the quality of relationship between the other person and ourselves" • Imaginations of the feelings imparted to works of nature, as though by a creator • Subcategory of empathy	–
Gaver (1996)	• Social affordances sub-factors	–
Hartson and Pyla (2012)	• Design features that connect our subconscious and intuitive appreciation of fun, aesthetics, and challenges to growth	– Interaction
Kytta (2003)	• Inclusive of not only the simple negative or positive emotional content but also the very delicate one	–
McGrenere and Ho (2000)	• Obtaining satisfaction for the intended purpose can be achieved action	–
Morie et al. (2005)	• Affective elements that lead to improving students' learning in the technology-enhanced learning environments	– Multimodal input components, VR graphics
Norman and Ortony (2003) and Norman (2004)	• Design elements that draw user's emotional responses or reactions	–
Schutte et al. (2008)	• Properties that facilitate or hinder an emotion-related process as perceived by its users • Properties relating to how emotion-related processes or behavior of a user are elicited (or suppressed), expressed (or inhibited), perceived, and managed	–
Seif El-Nasr et al. (2011)	• Inducing optimal flow experiences	–
Zhang (2008)	• Design elements to induce the optimal feelings that are intended through the first contact and the following intensive interaction	– Attractive appearance, gaming, immersive technologies
Cheng (2014)	• Properties that show the emotional effect on learning in an MOOC learning environment	–

et al. (2011) indicated that VR-based environments with EAs for learning pedestrian safety skills induced positive emotions among the learners. It is necessary to take into account EA design elements in such online learning environments to make learners feel more positive to learn.

Norman's (2004) user-centered thoughts on how to consider emotion in the design process should be regarded as some of the best advice currently available to design and develop emotionally affordable online learning environments. He suggested the three levels of the user interaction model for emotional design: visceral, behavioral, and reflective level. An increasing number of studies have investigated the design variables of various artifacts such as products,

websites, and systems for the three levels of EAs as shown in Table 3.

Research methods

The objective of this study was to develop and validate online learning design principles to enhance EAs by utilizing affordance-based design methodology as a solution for the emotional designs of online learning environments. Online learning design principles for EAs are initially developed based on a literature review and validated by an expert review. Then their usability is tested by instructional

Table 3 Design variables for three levels of EAs

Levels of EAs		Visceral level	Behavioral level	Reflective level
Research	Artifacts			
Demir (2008)	Objects	Responses—automatic	Experiences—occur through interaction	Relationship—builds over time
Desmet (2002)	Product	Objects—does it appeal to my attitude?	Agents—does it meet my standards?	Events—does it help reach my goals?
MacLean (1990)	S/W system	Reptilian Brain (unconscious, instant)	Mammalian Brain (conscious and unconscious)	Neo-Mammalian Brain (conscious, slow, deliberative)
Jordan (2000) and Tiger (1992)	Product	Hedonic benefits—sensory and aesthetic pleasures	Practical benefits—result from the completion of tasks	Emotional benefit—effects on user's emotions
Norman (2004, 2007)	Product, system, website	Visceral—aesthetic and tactile qualities	Behavioral—effectiveness and ease of use	Reflective-self-image, personal satisfaction, memories
Lim et al. (2008)	Interactive system	Visual beauty—qualities that people can see such as colors, sizes, shapes, visual material qualities	Usable interaction—qualities which make it possible for people to interact with the product (e.g., interfaces)	Useful function—capabilities and functionality such as learning, playing music, calling to someone, taking pictures
Van Gorp and Adams (2012)	Product, website	Aesthetics—how the product looks and feels	Interaction—how the user interacts with the product	Function—what the product does
Sanders (1992)	Product	Desirable—aesthetically appealing	Usable—capacity to be understood, learned, & utilized	Useful—accomplishes what it was designed for
Miller et al. (2006)	Educational S/W system	Visceral processing needs visceral design on appearance and attractiveness which makes an appeal to gut feelings	Behavioral processing needs behavioral design on pleasure and effectiveness (usability and performance)	Reflective processing requires reflective design on self-image, identity, personal satisfaction, memories

designers' evaluations by developing online learning program prototypes reflecting the design principles.

This study adopted "design and development research," proposed by Richey and Klein (2007) which represents the systematic study of designing, developing, and evaluating processes to establish an empirical basis of creating instructional and non-instructional artifacts in the educational domains. Among the suggested methods, the development of principles was carried out through a literature review. This review consisted of searching for and selecting relevant prior studies, drawing and classifying results and implications into variables, and synthesizing and elaborating related variables according to the core components of EAs in online learning environments. Validation of the principles was carried out through three rounds of expert reviews utilizing validation questionnaires and in-depth interviews, and then a usability evaluation with experienced instructional designers of online learning. Detailed research methods and activities of each step that this study applied are as shown in Fig. 1.

Participants

In order to validate the components and principles developed by literature review, two validation methods of expert review and usability evaluation were employed. Three-round expert reviews were conducted. The panel of experts was selected to test internal validity with respect to the design components and principles. Selected experts have expertise in the academic or practical fields of the educational technology (3), human–computer interaction (1), visual design (1), computer science (1), and online learning industry (1). The experts' profiles are shown in Table 4.

Three of the experienced instructional designers of online learning system or content participated in the usability evaluation of the principles. They have more than 5-year online learning design experiences either in academic or corporate settings as shown in Table 5.

Instruments

The researcher guided the experts on the validation processes, and asked them to review on the principles' theorization process, the overall principles, and each of the principles. They were asked to validate them by filling out the 4-point Likert scale questionnaire and commenting on the principles with the following validation instrument as shown in Table 6.

The principles' usability evaluation consists of designing PowerPoint-based storyboards following the principles as a simulated design tasks, completing the questionnaire, and commenting on the principles. The questionnaire from Tracey's (2001) research was adopted, and modified. The question items are shown in Table 7.
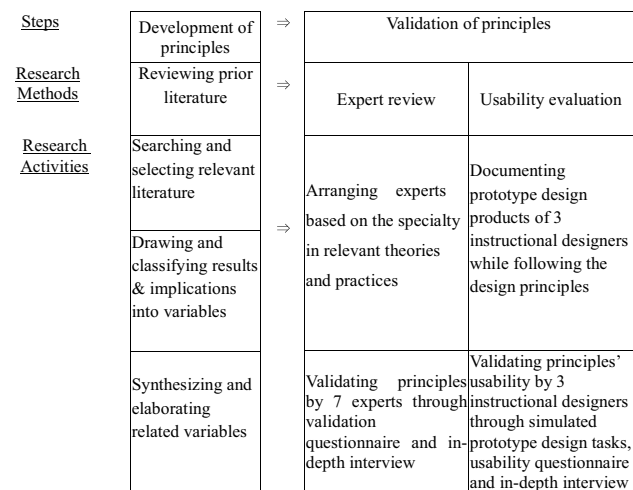

Fig. 1 Research procedure and methods

Table 4 Experts' profile

Experts	Final academic degree	Job & position	Expert fields	Expr. (years)	Participation in expert review		
					1st	2nd	3rd
Expert A	Doctor's degree	Research Professor	Model/principle development, instructional design	10	V	V	V
Expert B	Doctor's degree	Research Professor	E-learning, instructional design	7	V	V	–
Expert C	Doctor's degree	Assistant Professor	Instructional media, e-learning, digital textbook	11	–	V	V
Expert D	Doctor's degree	Research Professor	Computer science, e-learning system, IMS LD	8	V	V	V
Expert E	Doctor's degree	Affiliated Professor	HCI, UDL, e-learning m-learning	10	–	V	V
Expert F	Master's degree	Full Professor	Visual design, web design	12	V	V	V
Expert G	Doctor's degree	Researcher	Educational psychology, psychology of emotion, counseling	7	–	V	V
Expert H	Bachelor's degree	CEO	E-learning Industry field	13	–	V	V

Table 5 Instructional designers' profile

Instructional designers	Academic qualification	Instructional design experiences	Expr. (years)
Instructional designer A	Ph.D candidate in educational technology	Experienced planning and designing e-learning contents and systems	7
Instructional designer B	Ph.D student in educational technology	Experienced designing and developing e-learning contents and systems	8
Instructional designer C	Ph.D student in educational technology	Experienced designing and developing web-based learning environments	5

Table 6 The validation instrument for expert review

Steps	1st expert review	2nd expert review	3rd expert review
Purpose	• Principles' theorization process	• Overall principles and each of the principles	• Overall principles and each of the principles
Method	• 4-Point scale questionnaire • In-depth semi-structured interview	• 4-Point scale questionnaire • In-depth semi-structured interview	• 4-Point scale questionnaire • In-depth semi-structured interview
Question (items) type	• Multiple choice type—comprehensive literature review, appropriate terminology, appropriate interpretation and summary of reviewed literature, logical organization, appropriate reflection of literature review • Open-ended question type—improvement ideas	• Multiple choice type—validity, explicability, usability, generality, comprehensibility • Open-ended question type—improvement ideas	• Multiple choice type—validity, explicability, usability, generality, comprehensibility • Open-ended question type—improvement ideas

Table 7 The validation instrument for usability evaluation

Domains	Usability evaluation items
Overall design principles	1. The design principles make it easy to design EA in online learning environments
	2. The design principles enable to design EA in online learning environments
Expectations on online learning program reflecting the principles	3. Online learning program designed through the principles would have positive impacts on learners' emotional competence
	4. Online learning program designed through the principles would be more helpful than one designed without the principles

Data analysis

The content validity index (CVI) and inter-rater agreement (IRA) were used to analyze quantitative data of experts' and instructional designers' ratings. For this research, 4-point scale questionnaires were used for a valid report of CVI and IRA. Specifically, CVI is calculated by dividing the number of positive review ratings including 3 and 4 in the four-point scale by the number of experts (Haynes et al. 1995; Lynn 1986). The CVI value exceeding 0.80 is acceptably valid (Davis 1992; Grant and Davis 1997). IRA is measured by the number of items with agreement among raters divided by the total number of items. Higher than IRA 0.80 is acceptably reliable (Lynn 1986; Rubio et al. 2003).

Results

Initial design principles through a literature review

The initial theoretical design principles were constructed by analyzing and synthesizing the results and implications from related literature in the fields of affective psychology, emotional instruction, online learning, affective computing, and HCI. The resulting five design components and ten principles are shown in Table 8.

The ten design principles for designing EAs in online learning environments were developed by connecting design components of an expressive and manipulative user interface, learning activities, learning support, and social interaction support. The principles describe general rules for how

Table 8 The initial design principles via the literature review

EAs	Design components	Design principles
Visceral EAs	Expressive user interface	1. Principle of intimacy: design familiar (visual) screen elements which can help e-learners intuitively recognize and use
		2. Principle of aesthetic: design attractive visual screen elements that lead to e-learners' (visual) attention, interest, and joy
Behavioral EAs	Manipulative user interface	3. Principle of controllability: design to give e-learners opportunities to easily move their learning paths and control them to plan for the following study
		4. Principle of ease of use: design the usage of e-learning platforms that learners can be easily adapted to
Reflective EAs	Learning activities	5. Principle of playfulness: design playful learning activities and materials for learners to learn through play
		6. Principle of clarity: provide learners with clearly structured learning activities, visuals, or materials
	Learning support	7. Principle of humanity: use humanistic approach to facilitate student's emotional attachment to learning content and teacher
		8. Principle of balance: guide learners to harmonize their learning and personal life balance
	Social interaction support	9. Principle of self-disclosure: design for learners to disclose their image and emotions freely for social interaction
		10. Principle of solidarity: design for learners to seek social support or exchange sympathetic feedback by sharing learning experience and difficulties with colleagues

e-learning environments should be represented and designed to help learners understand, express, or regulate their emotions in online learning situations.

Validation results by an expert review

Experts were required to review the internal validity of both the overall and individual principles during three rounds. The results of the validation following the first round of expert review on the processes and results of the initial principles through the literature review are shown in Table 9.

The mean scores range from 2.8 to 3.8. One item had a CVI lower than 0.8, which suggests that it may need to be revised or deleted. The reliability of this scale is acceptable, for the total IRA = 0.8.

In the first round of the review process, the experts mainly critiqued the clarity of the principles and guidelines, the necessity or redundancy of the principles and guidelines, and abstract or complicated expressions. A revision of the design principles was conducted to highlight the uniqueness of the study in accordance with the experts' comments. In

consideration of the comments of experts A and F, "expressive UI" and "manipulative UI" were replaced with "learning screen" and "learning interface," respectively. After considering the comments of experts A and H, "interpersonal interaction support" was substituted for "social interaction support" in order to include cognitive, social, and affective components in interpersonally interactive online learning environments. In response to the comments of experts B and D, "solidarity" and "self-disclosure" were combined into "self-disclosure." To accommodate the feedback of experts A and F, many samples or examples were presented next to the principles.

The first revised design principles were validated again by the second round of expert review. As indicated in Table 10, both all of the CVI and IRA values were higher than 0.8 confirming that the overall design principles are valid and the reliability of this measurement is acceptable. Mean scores of four items were slightly lower thatn 3.0 which means suggests that they may need to be amended or improved.

The experts provided various detailed comments. Most requested the rephrasing of the principles for greater

Table 9 The 1st expert review results on the initial design principles

Criteria	Expert validation				M	SD	CVI	IRA
	A	B	D	F				
Comprehensive literature review	4	3	4	4	3.8	0.5	1.0	0.8
Appropriate terminology	3	2	3	3	2.8	0.5	0.8	
Appropriate interpretation of reviewed literature	3	4	4	4	3.8	0.5	1.0	
Logical organization	2	2	3	4	2.8	1.0	0.5	
Appropriate reflection of literature review	2	3	3	3	2.8	0.5	0.8	

Table 10 The 2nd expert review results on the overall 1st revised design principles

Criteria	Expert validation								M	SD	CVI	IRA
	A	B	C	D	E	F	G	H				
Validity	3	3	3	2	3	3	3	3	2.9	0.4	0.9	1.0
Explicability	2	3	3	3	2	3	3	3	2.8	0.5	0.8	
Usability	4	3	4	4	3	4	4	4	3.8	0.5	1.0	
Generality	2	3	4	3	2	4	3	3	3.0	0.8	0.8	
Comprehensibility	3	4	3	2	3	3	3	2	2.9	0.6	0.8	
Validity of the links between components & principles	3	3	3	2	4	3	4	3	3.1	0.6	0.9	
Validity of the links between principles & guidelines	2	3	3	2	3	3	3	3	2.8	0.5	0.8	

clarity and consistency. Some of the experts recommended that the design principles be combined. For example, "social interaction support" and "learning support" were combined into "learning support," and "balance" and "humanity" were combined into "humanity." Also, other experts suggested the terms of the design principles be revised. Thus, "aesthetics," "controllability," "ease of use," and "clarity" were changed into "affinity," "autonomy," "safety," and "positivity," respectively. The experts A, B, D, and E recommended the principles be reordered so as to correspond with the steps of the procedural model, as this would enable designers to easily apply the right principle to the right step in the process. The experts A, B, C, D, E, and F provided suggestions for presenting intended negative or positive emotions for each principle. The experts A, B, D, E, and F suggested that specific samples or technical examples for each principle be offered to enhance comprehension and explainability. In accordance with those experts' comments, the corresponding revision was carried out.

As shown in Table 11, the second revised design principles were validated again by the third round of expert review. Since all of the CVI and IRA values were higher than 0.8,

the overall design principles are sufficiently valid and reliable in terms of all criteria for the following criteria.

In addition to the validation scores, the experts provided detailed comments on the principles. Most of them asked that the phrases and sentences on the principles be restated for greater coherence and cohesion. In response to the comments of experts A and D, the term "autonomy" was revised to "personalization." Some experts suggested the framework be restructured by changing the column position of the examples to be behind the column of intended emotions, rearranging the intended emotions (experts A, G), based on their frequency or essentiality (experts B, F, G) and dividing the emotions into two categories: positive and negative (experts A, B, D, E).

Usability evaluation results by instructional designers

The refined design principles resulting from the three rounds of expert review were evaluated on their operational validity by four instructional designers who are field practitioners in the designing of online learning environments. The instructional designers, each with over 5 years of experience,

Table 11 The 3rd expert review results on the overall 2nd revised principles

Criteria	Expert validation							M	SD	CVI	IRA
	A	C	D	E	F	G	H				
Validity	4	4	4	3	4	4	3	3.7	0.5	1.0	1.0
Explicability	3	4	3	4	3	3	4	3.4	0.5	1.0	
Usability	4	4	4	3	4	4	4	3.9	0.4	1.0	
Generality	4	4	3	3	4	3	4	3.6	0.5	1.0	
Comprehensibility	3	4	3	3	3	3	4	3.3	0.5	1.0	
Validity of the links between components & principles	3	3	4	4	3	4	4	3.6	0.5	1.0	
Validity of the links between principles & guidelines	4	4	4	3	4	3	4	3.7	0.5	1.0	

performed a simulated prototype design task following the EA design model, and evaluated to what degree the model guided them through the process of EA design in online learning environments. The instructional designers' responses to the questions of usability evaluation on the principles are shown in Table 12.
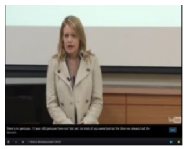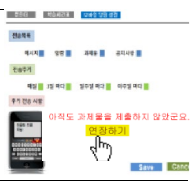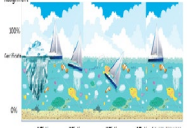
The instructional designers designed EAs in an MOOC-type online learning environment (http://snuon.snu.ac.kr/) and developed PPT-based storyboards partially as shown in Table 13.

The instructional designers also commented on the usability of the principles in the follow-up interview. They mentioned that the main strengths of these design principles, were as follows: the usefulness of checking out intended emotions for each design principle (instructional designers A, B, C), the convenience of designing EAs in online learning programs with the help of very well-organized and elaborated design components and principles (instructional designers B, C), and their ease of being understood and practically applied by novice designers (instructional designer A) are mentioned. However, instructional designers pointed out the difficulty in visualizing the learner interface or experience elements (instructional designers B, C) and in following the design procedure considering actual learning processes (instructional designers A, C). These comments on pointing out the weaknesses were considered for the revision, resulting in the offering of technical examples for each principle and the reordering of the sequence of principles.

Final design principles

According to the results of the study, the theoretically crucial components for designing EAs in online learning settings comprise learning activities, learning support, learning interface(LI)/learning eXperience(LX), and learning screen. While learning activities imply content-related design elements which are related to the quality, quantity,

Table 13 Storyboard samples created by the instructional designers

	Original version of SNUON	Applied principles	Redesigned version of SNUON
Designer A		Principle of Playfulness: Providing optional learning activities in a playful content types(web-toons, games, videos, animations) during 5, 10, 15, 20 minutes for breaks or energizers	
Designer B	-	Principle of Humanity : Providing time management tools for extending a deadline in case as well as keeping track	
Designer C		Principle of Intimacy: Using visual metaphor of sailing for learning progress	

difficulty, structure, processes, and types of learning tasks, learning support means supportive design elements which cover instructional interventions and communication with instructors and peers. Whereas LI/LX represents manipulative design elements to navigate the interface objects of an online learning environment, a learning screen represents the visual design elements of typography, images, infographics, graphs/charts, timelines, videos, progress bars, menus, buttons/icons, and characters in an online learning environment (Tables 13, 14).

Finalized design principles for EAs in an online learning environment are "positivity" and "playfulness" for designing the learning activities, "humanity" and "self-disclosure" for designing learning support, "safety" and "personalization" for designing LI/LX, and "affinity" and "intimacy" for designing learning screen design. Specific samples of technical examples are shown as in Table 15.
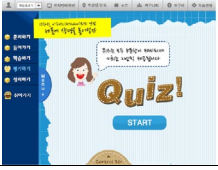
Table 12 Instructional designers' ratings on usability evaluation

Usability items	Instructional designers' evaluation			M	SD	CVI	IRA
	A	B	C				
1. The principles make it easy to design EA in online learning environments	3	3	4	3.3	0.6	1.0	1.0
2. The principles enable to design EA in online learning environments	4	4	4	4.0	0.0	1.0	
3. The program designed through the principles would have positive impacts on learners' emotional competence	3	4	3	3.3	0.6	1.0	
4. The program designed through the principles would be more helpful than one designed without the principles	3	4	4	3.7	0.6	1.0	

Table 14 The final design principles for EAs in online learning environments

Components	Principles	Intended emotions	Technical examples
Learning Activities	1. Principle of Positivity Design learning activities that can lead to positive imagination such as learning completion or success	Inducing or increasing hope, confidence Suppressing or reducing anxiety, fear, boredom, envy	• Structural map of modules/sections and periods/units on learning content according to the criteria of learning themes, goals/objectives, levels, material types • Flow chart of learning phases • Detailed and clear course completion criteria
	2. Principle of Playfulness Provide a pleasant individual and collaborative learning activities that give an opportunity of studying while playing	Inducing or increasing joy/delight, confidence, hope, satisfaction/contentment, sympathy Suppressing or reducing fear, boredom, frustration, anxiety, isolation, anger, shame	• Illustrations, photos, cartoons, sounds, videos, animations which show the different results happened when learners know and don't know the knowledge and skills • Stories, episodes, cartoons, comics, exercises adding fun elements • Collaborative learning activities such as discussion, forum, team project, group inquiry of the interesting issues, and topics • Challenging and interactive online quizzes, puzzles, quests • Learning activities of breaks or energizers during 5, 10, 15, 20 mins
Learning Support	3. Principle of Humanity Design a sympathetic professor formulation and feedback taking into account the human side	Inducing or increasing relief, joy/delight, confidence, satisfaction, hope Suppressing or reducing boredom, frustration anxiety, fear, anger, envy	• Welcoming messages or icebreaking questionings • Goal-oriented evaluation rather than criteria-oriented evaluation • Awarding badges or stickers depending on the performance level • Time management tools for extending a deadline as well as keeping track of start/due dates • Providing different instructional treatments/feedbacks such as content types, facial expressions, or messages of start/due according to expressed emotion
	4. Principle of Self-disclosure Design to feel free to expose his or her story/episode, opinion, information, difficulties	Inducing or increasing sympathy, relief, joy/delight, confidence, hope, satisfaction Suppressing or reducing isolation, boredom, anger, frustration, anxiety, fear, shame	• Mapping emotional states to the features of the avatar, character, mascot, photo • Netiquette rules for online communication manners • Setting privacy bounds of bulletin board, cafe, blog, SNS • Allowing anonymous(visitor) upload posts • Creating course atmosphere making the mistakes and failures considered as a learning opportunity • Providing synchronous communication tools as well as asynchronous communication tools for seeking help from others or providing help to others
Learner Interface/ Learner eXperience (LI/LX)	5. Principle of Safety Provide appropriate technical guidance and support when so can feel a sense of stability in the use of the program	Inducing or increasing confidence, relief, satisfaction Suppressing or reducing anxiety, fear, frustration	• Guidance and orientation on how to use the program by function descriptions of menus/icons on the mouse-over screen or video tutorials • Guidance bars/messages for the progress rate of learning • Quick help buttons/agents at the time when there are technical difficulties
	6. Principle of Personalization Design to be able to set the personalized learning environment themselves by freely moving to the learning path they want	Inducing or increasing confidence, relief, satisfaction, hope, joy/delight Suppressing or reducing boredom, frustration, anxiety, fear	• Navigation maps/bars for learning routes/progress • Providing customized controller with the buttons of play/pause, display/hide the subtitle/script, playback speed, replay • Concepts/themes of skins, layouts, showing/hiding of character agent, text fonts based on individualpreferences and emotions
Learning screen	7. Principle of Affinity Design an attractive learning screen that can give visually a favorable impression	Inducing or increasing joy/delight, satisfaction, relief Suppressing or reducing anxiety, frustration, anger	• Selecting ±5 dominant colors per web-page to symbolize the emotional atmosphere of screen concepts • Designing appealing fonts, typography, graphics creating visual rhythm • Applying responsive and adaptive web to change the format and layout based on the screen size
	8. Principle of Intimacy Design a visually familiar learning screen to be able to intuitively recognize	Inducing or increasing joy/delight, satisfaction, hope, relief Suppressing or reducing boredom, isolation, fear, anxiety, frustration	• Creating a visual or tactile metaphor for friendly feelings • Designing human-like (anthropomorphic) characters, facial expressions, gestures

Table 15 Samples of technical examples for the design principles

Learning Activities	[Positivity] Setting learning goal and timetable	[Playfulness] Break activities for fun
Learning Support	[Humanity] Empathetic feedback with emoticons	[Self-disclosure] Autobiographical board
LI/LX	[Safety] Quick help button	[Personalization] Navigation map for customized learning routes
Learning Screen	[Affinity] Appealing typography	[Intimacy] Anthropomorphic characters

Discussion and conclusion

This study intended to develop design principles and validate them for improving EAs in an online learning environment which could support students' emotional competence and facilitate learning by adopting affordance-based design theory. The design principles for EAs of an online learning environment were firstly developed through a comprehensive literature review and then reviewed by experts. After their usability was evaluated by instructional designers, we finalized the eight design principles: positivity, playfulness, humanity, self-disclosure, safety, personalization, affinity, and intimacy. Based on the research results, the importance and implications with respect to the following details are explored.

A theoretical and practical guide for designing an emotionally affordable online learning environment

The development and validation of design in an emotionally affordable online learning environment are conducted by not only analyzing prior literature but also carrying out iterative expert review and usability evaluation by instructional designers. This study provides more systematic guides so that multidimensional advice from researchers and field practitioners in educational technology, educational psychology, computer engineering, HCI, and visual design might be used to design and develop an affordable online learning content and platform. The design principles integrate knowledge from diverse theoretical backgrounds such as educational technology, ecological psychology, affective psychology, educational psychology, neuroscience, cognitive science, affective computing, and HCI, and make that knowledge systematically applicable in practice. Also, the design principles are intricately customized for instructional designers' use. In accordance with the comments of instructional designers, the order of the design principles is rearranged or moved, taking into account the actual processes of their design and students' learning. Moreover, the technical examples are included to help them visualize LI/LX and screen design. This hybrid systematic prescription would be a theoretical framework for designing online learning programs, sites, or systems with positive EAs, and it may become practical online learning design tips or guides.

Integrating affective factors into instructional design by taking into account learners' emotional competence

This study guides instructional designers through the design process from broader instructional perspectives throughout affective domains as well as cognitive domains. Researchers are increasingly concerned to understand the benefits and importance of emotional design of instruction or affective instructional design in online learning environments as well as traditional face-to-face classrooms (Astleitner 2000; Glaser-Zikuda et al. 2005; MacFadden et al. 2005; Nummenmaa and Nummenmaa 2008; Pekrun 2011; Reilly et al. 2012; Rowe 2005). This trend could prevent instructional designers from focusing on only cognitive instructional design elements. Emotional design factors of online learning can contribute to the expansion of an instructional design theory as an emotional design of instruction. EAs in online learning are emotional factors of instructional design for considering online learners' emotional competence. As the emerging role of new technologies in education is becoming more important, emotionally affordable online learning environments from a learner-centered perspective are needed to help cultivate learners' positive emotions or/and lower their negative emotions. The suggested design principles for emotionally affordable online learning environments are expected to make online learners perceive and monitor their own and others' emotions, and express and regulate their own emotions.

Applying an affordance-based approach to develop online learning programs

Dynamic innovation and cutting-edge technologies enable designers and developers to design more affordable and supportable learning environments. For learners to achieve meaningful and successful online learning, emotional support should be provided. This study developed design principles for designing EA-based online learning environments by integrating technical and educational properties and elements from a variety of academic and professional fields on emotions and emotional design. The present study is significant in the sense that it could provide an actual and comprehensive guidance for developing online learning programs, websites, or systems that take emotional aspects into consideration.

In designing and developing technology integrated or enhanced learning environments in the field of instructional design, educational attributes are more emphasized compared to technical attributes (Kabilan et al. 2010; Lee 2014; Nummenmaa and Nummenmaa 2008). The technical affordances which fairly influence interactivity of online learning are often overlooked in the process of its design and development. For high-quality online learning courses, educational attributes and technical attributes must be considered in a well-balanced manner. This study claims that designers and developers of online learning content and platform take an integrative affordance-based approach combining both its technical and educational affordances.

Limitations and recommendations for future research

This study faces limitations that suggest the direction of future research. The research is restricted to the internal validation of design principles through expert review and usability testing. It attempted to bridge theoretical and practical approaches such as the literature review, the expert review, and the usability testing of simulated prototype design tasks. Prior studies mentioned that internal model validation demonstrates the integrity and usefulness of the instructional design components, principles, and other artifacts, while also guiding instructional designers with descriptions of details involved in the design processes. In spite of these advantages, external validation through empirical research should be additionally conducted to examine the effectiveness of the design principles. Future research is needed to implement field evaluations or experimental tests which can investigate learners' reactions and experiences on an online learning site, content, platform, or program applying the design principles. Furthermore, it is necessary to extract factors that have significant effects of EAs on online learning environments and develop reliable and valid questionnaires through exploratory factor analysis and confirmatory factor analysis. Thus, future research can examine and empirically verify the effectiveness of the design principles through learners' evaluations of a developed online learning course applying the design principles. In consideration of the stages of learners' affective development, empirical studies on learners of various age groups are required.

The design principles developed and internally validated through this research have the basic goal of maintaining and enhancing learning by inducing learners' positive emotions and mitigating negative emotions. However, it has been examined that in certain circumstances, negative emotions such as confusion, discomfort, and frustration produce positive educational effects of facilitating learners' metacognition and learning. Therefore, it is necessary to focus on appropriately regulating learners' emotional states or adaptively supporting their emotions for learning instead of simply maximizing their positive emotions and suppressing their negative emotions.

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