THE ASSESSMENT SCALE FOR CREATIVE COLLABORATION (ASCC) VALIDATION AND RELIABILITY STUDY

The Assessment Scale for Creative Collaboration (ASCC) Validation and Reliability Study

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Abstract

Creativity, a primary academic objective, is crucial in higher education, as economic, informational, societal and environmental advancements rely on people’s ability to innovate. Creativity is widely investigated in its individualistic form, yet there is a notable dearth in work that studies its collective dimension, from a learning perspective. This study focuses on validating the psychometric properties of an existing instrument (ASCC), by measuring creative collaboration in blended learning settings. Two hundred and thirty six under and post-graduate students self-evaluated their creative collaboration experiences, using the ASCC instrument. The findings of exploratory factor analysis denote a three-factor (21-item) structure, measuring ‘Synergistic Social Collaboration’, ‘Distributed Creativity’, and ‘Time Regulation and Achievement’, with good internal consistency.

An instrument with valid psychometric properties for the assessment of creative collaboration is much-needed in the growing research and practitioners’ community. This is critical in the fields of Design, HCI and Engineering, that rely extensively on the creative collaboration (online and offline) of teams to develop innovative products that are suitable for real-world purposes.

Keywords: Creative collaboration, social creativity, higher education, HCI, instrument development
Introduction

Creativity has been at the center of the Higher Education (HE) agenda for more than a decade, as a prerequisite for innovation and growth and a strong attribute required of graduates entering the knowledge industries today (Binkley et al., 2012; Botma, Van Rensburg, Coetzee, & Heyns, 2015; WEF, 2016). Being a multi-dimensional construct, respective research challenges lie in identifying the elements required for its fruitful practice, and most importantly, its evaluation. However, scholars raise a point about the area of creativity being in need of more exhaustive and targeted investigation (Batey, 2012; Sternberg, 2005). Specifically, to-date, there is a lot of work, focusing on organizational settings, while the area of creativity in education, particularly in the areas of Design, HCI, and Engineering studies, falls short of investigation. Additionally, collective or distributed – versus individual – creativity, appears largely under-explored in literature, especially at times when social learning approaches are prevalent in HE (Harvey, 2014; Sawyer & DeZutter, 2009; Yuan & Zhou, 2015). Social creativity or “creative collaboration” (Wishart et al., 2011) cannot be overlooked, as it can produce far richer results, than those generated by the sum of multiple individualistic contributions (Csikszentmihalyi & Hunter, 2003).

The role of creativity in HCI research, education and practice is central. It is an underlying factor for the people-driven, problem-oriented, experimentative and collaborative development of novel, usable and safe products (systems, tools) for the end-user (McCrickard, Wahid, Branham, & Harrison, 2013; Oulasvirta & Hornbæk, 2016). Although deemed important decades ago, creativity has only recently claimed a position in HCI (a computer science discipline) education and practice. Yet, creativity research, under the lens of HCI, lacks perspective and unity, as it is largely concerned with designing creative systems, rather than aiming to support the entire creativity
processes of users (Hoffmann, 2016; Kantosalo & Toivonen, 2016). In order to achieve that, it should adopt an inter-disciplinary approach, encompassing both perspectives of HCI - *humans* and *computers* - drawing from research on both generic (psychology) and computational (computer science) creativity, thus accelerating the “process of disciplinary convergence” (Shneiderman et al., 2006).

Through this work, we attempt to contribute towards this effort, as we aim to inform about one of the ways that *human, creative collaboration* to be exact, can be measured and understood, through the use of a psychometric instrument. Further, since this instrument concerns *blended education*, the role of technology in supporting creative collaboration is central. Although the instrument does not focus on the affordances of a particular tool, but rather on the *creative collaboration* that ensues as a result, it is still of primary interest to HCI research.

This instrument probes for perceptions of creative collaboration in student teams who work in blended learning settings. Part of the motivation for this stems from our interest in employing the instrument in the area of Design education and related fields, such as HCI and Engineering. These fields are largely human-centered and rely extensively on the team’s social infrastructure and their ensuing collaborations, for the development of innovative products that are suitable for real-world purposes (Jeon, Fiebrink, Edmonds, & Herath, 2019; L. Dym, Agogino, Eris, Frey, & Leifer, 2005; McCrickard et al., 2013).

In specific, through this work we seek to validate the psychometric properties of this instrument, namely, the *Assessment Scale for Creative Collaboration* (ASCC), that resulted from the work of the European-funded CoCreat LifeLong Project (Wishart et al. 2011). Reliability findings, based on the scale’s initial 25-item structure, were reported in the original work – yet – the instrument’s psychometric properties were
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never assessed. This study aims to perpetuate the results of the original work by seeking to:

a) Present the ASCC ‘s subscale structure and derive respective reliability results
b) Explain the conceptual relationships of the subscales’ variables, guided by the original work and how these relate to creativity-oriented HCI research

Overall, it is important for researchers to possess established and scientifically sound measures to address various creativity dimensions, in order to enable and foster them accordingly in HE. Specifically, when learning is guided by social perspectives, an instrument that measures creative collaboration in teams in natural settings, is largely missing from literature and can make a valuable contribution to the field.

The following sections focus on related research in the areas of creativity, through a general as well as an HCI perspective. The ASCC is then thoroughly described, followed by the methodology used for its validation. Finally, the quantitative findings and the scale’s factor structure are discussed.

Related work

Generic and HCI-oriented creativity

Creativity is a critical skill and claims a prominent place in educational research (Crilly & Cardoso, 2017). Although primarily linked to artistic endeavours, research suggests that it is also crucial in the science, technology, engineering, business and education disciplines (Cropley, 2015; Kaufman, Plucker, & Russell, 2012; Wagner, 2017).

Most contemporary theories share the view that creativity is seen as the ‘expressions or outcomes that are both novel as well as appropriate for a purpose’ (Amabile & Pillemer, 2012; Bruner, 1962; Furnham, Batey, Booth, Patel, & Lozinskaya, 2011; Kaufman & Baer, 2005). Amongst many, its most important sub-
constructs refer to *innovation* and *divergent thinking*, perceived as a type of lateral, experimental, intuitive, risk-taking, affective and generative approach (Onsman, 2016).

_Convergent thinking_, on the other hand, a similarly vital component of creativity, is seen as an associative, integrative, critical-thinking step, that focalizes and extracts judgments from arbitrary and diverse ideas, guided by the specific *purpose* of the task at hand (Jaarsveld, Lachmann, & van Leeuwen, 2012).

* Appropriateness for a *purpose* - often a real-world one - is a crucial component of creativity (Chilana, Ko, & Wobbrock, 2015; Finken, Culén, & Gasparini, 2014).

Sufficient prior *subject-knowledge* is also important for achieving this *generative* and *integrative* activity (divergent/convergent thinking), as the *reuse* of earlier knowledge facilitates the production of new knowledge in the context of a purpose (McCrickard et al., 2013).

These key sub-constructs highlight and justify the inevitable link between creativity and HCI. Before we begin analysing this rationale, we need to mention that their connection can be understood in light of two perspectives. Firstly, creativity as an *integral component* of *HCI education and practice*, and secondly, creativity as the *object* of *study in HCI*, that is, the ways in which HCI can support human creativity via technology. Both link back to the rationale of this research and are explored below.

**Creativity in HCI education and practice**

HCI education and practice presuppose the actions of both *finding* and *making*; that is exploring and understanding human-computer-related phenomena and using these to support the *ideation* and transformation of concepts “into new constructs” (Finken et al., 2014). This occurs through critical questioning and problem-solving processes, to develop and deliver novel, safe and usable products to the end-user (McCrickard et al., 2013; Oulasvirta & Hornbæk, 2016).
Interaction design in HCI, has been recently seen to follow design thinking, a model that promotes open-endedness and “creative-insight” (Finken et al., 2014; Pierce et al., 2015) as fundamental for the development of novel products that can respond to the complex user needs of today (Candy, 2013; Frich, Biskjaer, & Dalsgaard, 2018). Design thinking involves a cyclical, yet, non-linear process of inspiration, ideation and implementation. Collective brainstorming, the expansion of the problem-space through multiple perspectives and ideas, visual externalizations (i.e. prototyping) and user-testing, are considered as key for the production of innovative solutions (Bhatnagar & Badke-Schaub, 2017; Zimmerman & Forlizzi, 2014). Agreeing with this model, the interaction design processes are also predominantly collaborative, materializing in - ideally- multidisciplinary team conditions (i.e. HCI researchers, programmers, designers, psychologists) to stimulate diverse inspiration and knowledge (Bardzell, Bardzell, & Koefoed Hansen, 2015; Culén, 2015; Pierce et al., 2015). Since contemporary HCI relies on a people-first, innovation-oriented and experimentation-driven rationale, it is fair to say that creativity and collaboration are therefore crucial components of HCI research, education and practice.

**Creativity as the object of study in HCI**

Creativity and collaboration – specifically the ways in which they can technologically be supported - are relatively new in HCI (Frich et al., 2018). As creativity-oriented-HCI research has so far been concerned with computational creativity, that is solely on designing creative systems, it is considered to be ‘fragmented’ as it lacks the perspective of supporting the entire process of human creativity – both individual and collective. This can evidently be augmented through the contribution of work from generic creativity research (CR), a subdomain of psychology research (Hoffmann, 2016).
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Specifically, to design systems that enable and promote creativity, HCI needs to 
broaden its investigation with fundamental CR variables, such as the people, processes, 
products and context (Rhodes, 1961). Drawing knowledge from multiple domains 
constitutes a more compound research approach and helps shape a well-rounded and 
substantiated understanding of human creativity and collaboration, accelerating the 
“process of disciplinary convergence” in this way (Shneiderman et al., 2006). There is a 
current critical need for joint research, accommodating phenomena that fall under the 
 lens of creativity on both computers and humans, as the two main areas of interest in 
HCI (Hoffmann, 2016).

**Creativity assessment perspectives and strategies**

The assessment of creativity has generated considerable discussion over the years 
(Runco, 2007). Dimensions such as the individual creative-cognitive abilities, 
personality traits and inclinations (Crilly & Cardoso, 2017), the creative process 
(Mednick, 1962), the social context (Plucker, Beghetto, & Dow, 2004), the epistemic 
domain (Furnham et al., 2011; Kaufman & Baer, 2005) and the creative outcomes 
(Horn & Salvendy, 2006; Zeng, Salvendy, & Zhang, 2009), indicate that creativity 
warrants dedicated specificity in its research and analysis (Mumford, 2003).

Assessment strategies have so far included verbal or written protocol analysis 
(D’souza & Dastmalchi, 2016; Gero & Kan, 2016), behavior and activity-based tests 
(Torrance 1966), observation (Meneely & Portillo, 2005), psychometric instrumentation 
(Plucker et al., 2004; Runco et al., 2014) and external creativity assessment of products 
(Amabile, 1982; Horn & Salvendy, 2006; Zeng et al., 2009). The majority of these look 
into individual dimensions of creativity such as personality attributes and performances 
(Runco, 2007). Some of the most prevalent tests operationalized towards this direction, 
include the ‘Torrance Test of Creative Thinking’ (TTCT) (Kim, 2006; Torrance, 1966),
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the ‘Kaufman Domains of Creativity Scale’ (K-Docs) (Kaufman & Baer, 2005), and the 
‘Creativity Assessment Battery’ (rCAB)© (Acar & Runco, 2014).

Social collaborative creativity assessment

The assessment of social creativity is still under-explored in literature (Farh, Lee, & 
Farh, 2010; Harvey, 2014; Kurtzberg & Amabile, 2001; Paulus & Baruah, 2018; Yuan 
& Zhou, 2015). A few studies have concentrated on qualitative observations of 
brainstorming teams to document their collaborative creativity (Paulus & Nijstad, 
2003). Others detected and categorized distributed creative collaboration, through 
protocol coding, using interaction models (Sawyer and DeZutter 2009) and computer-
mediated analysis of activity and discourse (Karakaya & Demirkan, 2015; Scott, 2015) . 
As part of an inclusive approach, Batey (2012) provides an effective, all-encompassing, 
three-dimensional taxonomic framework for the analysis of creativity, depending on the 
research objectives. It covers three axes : a) level, referring to the individual, team, 
organization or culture dimensions b) facet, referring to the trait, process, press or 
product dimensions, and c) measurement, referring to the objective, self-rating and 
other-rating dimensions. With regard to team and collaboration, he proposes that results 
can be extracted from a team-rated creativity questionnaire, through the sum of the 
individually submitted scores. In this work, we adopt this recommendation and proceed 
to validate the ASCC, to be used in such approaches. As discussed, the scale probes for 
accumulated perceptions of a team’s creative collaboration processes, in blended 
learning settings. From an HCI perspective, basic usability (effectiveness, efficiency 
driven) and task-oriented assessment methods (i.e. user clicks, time-to-completion etc) 
are not sufficient for capturing its complex nature, as a multi-faceted creativity 
construct. These methods have often been criticized for limiting understanding based on 
objective and controlled, (i.e. in-vitro) findings only, which are in conflict with the ill-
structured, open and exploratory nature of creativity (Fröch et al., 2018; Shneiderman et al., 2006). Research on this multi-dimensional construct, should aim to investigate the real situated experiences of the people involved instead, particularly in terms of the cognitive, perceptual and affective perspectives (Candy, 2013; Hassenzahl, 2004).

Contributing to the required shift from *task* to *value*-oriented techniques are - amongst others - the category of reusable, *self-reported* measures, such as psychometric instruments, that HCI researchers can use to extract information about targeted dimensions of *creativity* and *collaboration*, especially when they are also supported by technological means (Cherry & Latulipe, 2014). An instrument with psychometric properties aimed at measuring *creative collaboration* in blended learning settings, is therefore a much useful tool. That said, depending on the objectives of a study, research rigor can be further enhanced by triangulating findings from various other techniques (observation, interviews, focus-groups, artefact assessment), that can contribute new findings and make a difference to HCI research (Candy, 2013; Shneiderman, 2007).

Overall, an instrument with psychometric properties aimed at the assessment of *creative collaboration* is highly needed in the research of creativity in blended settings in HE, as it is virtually absent from current literature. In the next section, we briefly describe the *Assessment Scale for Creative Collaboration* (ASCC), as the CoCreat Lifelong Learning Project’s attempt in the development of a self-rated instrument.

**The Assessment Scale for Creative Collaboration (ASCC)**

The ASCC (Wishart et al. 2011) investigates perceptions of the key concepts of *creative collaboration* in computer-supported collaborative learning (CSCL) settings. Wishart et al. (2011) focus on the dimension of ‘creative collaboration’ by adhering to primary CSCL theories (Dillenbourg, Järvelä, & Fischer, 2009; Lew, Park, Lee, & Kang, 2013). They explain their choice of the term, as the ‘collaboration process between people,
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working on collective tasks in the creative or other industries’. They posit that this process is initiated by ill-defined problems, driven by a series of acts of imagination, divergent thinking and problem solving, leading to novel as well as useful outcomes.

The instrument looks at creativity from different angles, drawing from social perspectives, factors of interest, together with learning regulation theories, to derive a compound result. Specifically, through its original 25-item structure, it seeks to elicit participant perceptions of the team processes that relate to divergent and critical thinking, the management of ill-defined problems, the role of prior subject-level knowledge, the social perspectives of co-located and distant collaboration, the level of interest and engagement in a task, and individual or group time-pressure and management.

Materials and methods

Participants
A total of 236 undergraduate and postgraduate students, with recent sufficient collaborative work history, completed the ASCC’s questions using a 7-point Likert scale. The participant sample falls close to the ten observations-per-item approach, which indicates a ‘fair to good’ analogy (Barlett, Kotrlik, & Higgins, 2001; Gorsuch, 1983; Pearson & Mundform, 2010). Participants were prompted to consider their most recent collaborative experience as part of their academic responsibilities, for completing the questionnaire.

Parallel analysis
We conducted Parallel Analysis, prior to factor analysis, to identify the statistically significant factors (eigenvalues) that should be obtained from the scale (O’connor, 2000; Wood, Akloubou Gnonhosou, & Bowling, 2015). We used a permutation
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approach for running the Parallel Analysis (PA), as it is reportedly an appropriate and robust method for multivariate non-normal data (O’connor, 2000). A three-factor structure (agreeing with the eigenvalue of >1 criterion (Kaiser, 1960), was extracted from the 25 variables of the ASCC questionnaire.

Results

Exploratory factor analysis (EFA)

Descriptive statistics resulted in item means of an average range of 4.2 – 5.7 (M=5.1). A standard deviation of above 1, also indicated satisfactory diversity in the responses (SD=1.46). No variable redundancy was detected in the correlation matrix table (Pett, Lackey, & Sullivan, 2003).

We adopted a Principal Axis Factor (PAF) extraction and the Oblimin Oblique rotation method (delta=0) in the EFA, based on the prediction that ASCC variables would be correlated, as it frequently occurs in social studies (Reise, Waller, & Comrey, 2000). The results indicated a general positive manifold in the data. The measure for sampling adequacy (Kaiser-Meyer-Olkin) produced an optimal result (.913) (Dziuban & Shirkey, 1974). We also extracted a significant value ($\chi^2 (300) = 3117.52 p < .001$) after conducting the Bartlett’s test of sphericity, in measuring homogeneity in the correlation matrix (Scott, 2015).

The three resulting factors comprised 47.28% of the total variance in the ASCC variables. Factor eigenvalues and corresponding total variance percentages are presented in Table A1.

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The within-variables approach indicated a moderate to high level of common variance based on the extracted communality values: >.5 accounted for the 48%, > .4 accounted for the 40% and <.4 for the rest (Thompson, 2004).

The rotated pattern matrix (pattern coefficients) results indicated an initial set of 11 variables for Factor 1, 7 variables for Factor 2 and 7 variables for Factor 3, with some degree of cross-loadings. We only retained variables that had:

a) a pattern coefficient of 0.4 and above

b) significant differences in the value (approximately ≥ 0.20), in cross-loading items (Loiacono, Watson, & Goodhue, 2002; Netemeyer, Bearden, & Sharma, 2003)

During post PAF processing, we made qualitative judgements about the deletion and retention of variables (see Table A2). The final resulting subscale structure, following reliability analysis, is presented in Table A4. Variables 3, 6 and 9 (see Table A2) were the only ones that did not cross-load on other factors. However the rest, were retained at this stage, as they complied with retention criterion (b).

Factor 2 loaded with a total of 7 items. We chose to retain item 18 that failed criteria (a) and (b), because of its critical conceptual significance (divergent thinking) in the construct of creativity.

Factor 3 loaded with a total of 7 items. Variables 24 and 25 did not comply with retention criteria (a) and (b) and were therefore dropped from this factor. Factor 3 resulting structure included a total of 5 variables.

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Reliability analysis

We investigated the ASCC’s subscales’ reliability (internal consistency reliability) and sought to comply with the following criteria:

a) A minimum of $\alpha = 0.70$ for Cronbach’s alpha coefficient for all subscales (Cronbach, 1951). Newly developed scales may produce values of as low as 0.7 (Fornell & Larcker, 1981; Lance, Butts, & Michels, 2006). Likewise, values that fall higher than 0.9 need to be revisited to examine issues of redundancy.

b) A range of values between 0.3 and 0.7 for inter-item correlations, denoting homogeneity but no redundancy (Pett et al., 2003).

c) Small values ($\leq .1$) for inter-item-correlation standard deviation (Pett et al., 2003)

d) A range of values between 0.4 and 0.75 for corrected item-to-totals as indicated in the item-to-total statistics results (Loiacono et al., 2002; Netemeyer et al., 2003).

Below we present individual subscale reliability results.

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Subscale 1

We concluded an optimal level of internal consistency at $\alpha = .92$ for this subscale (Cronbach, 1951). With the exception of items 1, 2 and 4 (with values above 0.7), the rest of the items in the subscale fell within the acceptable inter-item-correlation range. The item-to-total correlation results indicated that items 1 and 2 exceeded the acceptable upper limit and were removed from the subscale. Item 4 was retained as a critical conceptual variable (interest) relating to the construct of creativity. A second
reliability analysis test on the subscale’s 9 variables, produced a high Cronbach’s value of $\alpha = .89$ (see Table A3).

*Subscale 2*

Reliability test analysis on the subscale’s 7 items resulted in a satisfactory Cronbach’s value of $\alpha = .77$ (see Table A3). Item 14 of the subscale failed to comply with the lower value criterion in the *inter-item-correlation* range. However we judged that the variable should be retained, due to its association with both the creativity and collaboration constructs (Hsiao, Wang, & Chen, 2017; Ohly & Fritz, 2010; Prem, Ohly, Kubicek, & Korunka, 2017).

*Subscale 3*

Reliability analysis on the subscale’s 5 items resulted in a satisfactory Cronbach’s value of $\alpha = .76$ (see Table A3). The subscale presented an item (22) that failed to meet the minimum value (0.3) in the *inter-item-correlation* matrix (0.29), but was maintained as it is strongly associated with creativity and related constructs in literature (Losada, 1999; Valiente, Swanson, & Eisenberg, 2012) (see Table A4).

The test for reliability produced high alpha values ($\alpha \geq .70$) for all subscales, hence, overall, the instrument presents high internal consistency reliability.

Discussion

The objective of this work was to perform an initial validation of the ASCC’s psychometric properties, due to the vast lack of self-reported instruments that measure
creative collaboration in teams, based on existing research. The EFA produced three subscales (totaling 21 items) for assessing ‘Synergistic Social Collaboration’, ‘Distributed Creativity’, and ‘Time Regulation and Achievement’. The instrument presented high internal consistency reliability, based on Cronbach's alpha values, with sound conceptual inter-item relationships. These are discussed below.

**Subscale 1: Synergistic social collaboration**

The choice of term for this subscale relies on the crucial role of the *synergy* amongst collaborating team-members for the production of greater results than the mere sum of separate individual parts. The nine-variable subscale contains factors of *co-present* and *remote* CSCL. At its core lies a set of variables related to *cognition*, such as a developed sense of understanding peers’ viewpoints, grounded in affective factors such as *trust*, *support* and a ‘sense of belonging’ in the team (see Table A4).

*Interest*, an intrinsic motivational variable, is closely related to creativity and collaboration in literature and frequently occurs in the subscale (Hoskins & Van Hooff, 2005). The construct of *interest* (often linked to engagement) encompasses both affective and cognitive attributes (Krapp, 1999), denoting awareness of one’s own knowledge and competencies, as well of what can socially and conceptually be transmitted (i.e., ‘Shared knowledge and goals’) (Renninger, Hidi, Krapp, & Renninger, 2014)(Wentzel & Miele, 2009). Eccles’ expectancy-value model (1983) denotes *interest* as a fundamental component of its *task-value* factor (i.e. the perceived worth of an academic task), as well as the force that drives the successful *completion of tasks* (i.e., ‘Orientation towards task success’) (Wigfield & Eccles, 2000). The high correlation values between the two variables - ‘Group Interest’ and ‘Task Success’ ($r = .664$) - in the *inter-item correlation* matrix also confirm the strong conceptual link between the two (see Table A5).
The produced links between the variables in the subscale, are well supported by evidence from literature. For instance, the extensive generation and analysis of ideas (‘Discussion of early ideas’) is related to natural inquisitions and explorations on behalf of learners and collaborators, which is the outcome of a growing interest and engagement in a subject area (Gehlbach et al., 2008). Another activity initiated by group interest – and also confirmed by the high correlational value ($r = .558$) in the subscale’s inter-item correlation matrix (see Table A5) - is the ‘Discussion of early ideas’ which is crucial in both creativity and collaboration in the learning context. The ASCC report posits that this variable - typically related to brainstorming activities - is prominently linked to literature on collaborative creativity (Mamykina, Candy, & Edmonds, 2002; Wishart & Eagle, 2012).

‘Adequate knowledge base’ is also repetitively encountered across theoretical domains. A sufficient level of prior field-specific knowledge, is for instance mentioned by Amabile (Amabile, 1982), in her componential theory of creativity, as a primary variable, rooted in social constructivist learning theories (Vygotsky, 1978) and a vital precursor to higher-level cognitive functions, during collaboration (Huang, Yang, Chiang, & Su, 2016). The results of this study (see Table A5) agree with existing work (Linnenbrink-Garcia, Pugh, Koskey, & Stewart, 2012) and confirm that prior knowledge, is a strong antecedent to interest and engagement in social learning settings.

Subscale 2: Distributed creativity

This subscale is titled ‘Distributed Creativity’, after Sawyer’s and DeZutter’s (2009) definition, as pertinent conceptual variables are prominent within this.
The majority of work theorizing about creativity, focuses on ‘Divergent thinking’ and the generation of innovative ideas that are appropriate for a task (i.e., ‘My group generated different and novel ideas in response to the task’). Theory also posits that ‘messy’ types of problems that lack explicit guidelines for their resolution (as those encountered in the real world), can augment and advance the collective creative thinking process (‘Problem boundaries stretched or broken’) (Brown & Duguid, 2001). Additionally, collective creativity that generates innovation, is known to flourish in a trustful and respectful environment – yet – one of a moderate ‘Degree of disagreement and tension’ (Chiu, 2008). This stems from the argumentative exchange that requires sound reflective reasoning on behalf of peers to prove and support their stances, during a collective creative task (Wishart et al., 2011). This view is also enforced in the study, due to the high correlation value between ‘Degree of disagreement and tension’ and ‘Level of divergent thinking’ (r = .452) (see Table A6).

Tension in itself, can also be seen as a by-product of engagement and interest in a task, which is also contingent to the ‘level and type of co-presence’ (formal/informal and offline/online) – (i.e. ‘Degree of co-presence’), meaning the availability and engagement of peers in the team’s practice.

Time-pressure and creativity make another prominent pair in this subscale. Time-pressure is explained either as actual, imposed by external factors such as deadlines (Romero and Barberà, 2012), or subjectively perceived by individuals as ‘lack of time’ in managing their tasks (university projects or work-related outcomes).

Existing work draws a two-fold relationship between time-pressure and creativity. From one perspective, creativity is seen as hindered in contexts with severe time pressure, as it forces teams to work faster by making quicker, less-exploratory - hence – safer but less innovative choices (Amabile, Hadley, & Kramer, 2002; Baer &
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Oldham, 2006). Another view posits that mild-to-moderate time pressure on the other hand, can act as a “challenge stressor” (Prem et al., 2017), sparking motivation and creative effort (Gardner & Cummings, 1988; Hsiao et al., 2017; Ohly & Fritz, 2010).

In terms of co-presence – both formal and informal – apart from the foreseen inter-item correlation amongst the two (r = .544), we were able to elicit that a ‘Degree of (informal) co-presence’ is associated with ‘Externalizing representations’ (r = .473). Interestingly this also happens between the latter and ‘Level of divergent thinking’ (r = .476), in the sub-scale (see Table A6). As proven, creativity (in the form of divergent thinking) and externalizations in informal social collaboration are solidly inter-related in previous work (Vyas, Heylen, Nijholt, & Van Der Veer, 2009). Physical or digital externalizations (i.e. sketches, notes, three-dimensional paper prototypes) are used to mediate and reflect novel thoughts onto tangible objects. These “guiding, constraining, and determining” cognitive dimensions, form communicative, coordinative, explorative and reflective creative activity and occur amongst team members, in informal co-present contexts (also confirmed by the subscale’s inter-item correlations) (Amitani & Hori, 2002; Zurita, Baloian, Pino, & Boghosian, 2016).

Finally, the subscale demonstrates good inter-item correlations between ‘Group-based time pressure’ and ‘Stretching problem boundaries’ (r = .463), while the latter also correlates well with a ‘Degree of disagreement or tension’ (r = .443) (see Table A6). We notify the reader that ‘Stretching problem boundaries’ refers to the exploration of different possibilities, as opposed to ‘Stretching boundaries’ in subscale 3, which suggests surpassing the assigned task deliverables.

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Subscale 3: Time regulation and achievement

The title of this factor stems from the positive interaction between learning regulation (with time regulation as a main sub-construct) and achievement, based on relevant literature (Pintrich, 2004). ‘Time regulation and Achievement’ is a subscale comprising five variables. As anticipated, the highest inter-item correlation (r = .636) in the subscale appears between ‘Individual’ and ‘Group-level time management’ (see Table A7).

Time-management and its three dimensions, self-regulation, co-regulation (pairs) and “socially shared regulation” (Hadwin, Järvelä, & Miller, 2011), appear as key constituents of learning regulation in literature (Pintrich, 2004; Stoeger & Ziegler, 2008). Social regulation reveals well-planned collective strategies, concerning time and effort, in purpose of attaining individual or collective knowledge and goals (Romero & Barberà, 2012).

Further, behavioral research illustrates the connection between regulation (‘Group time-management’) and innovation, as an accomplishment that surpasses the original expectations (‘Stretching boundaries’) (Britton & Tesser, 1991; Pintrich, 2004). Knowledge of self-ability, the purposeful planning of steps towards an end-goal, and adhering to that plan, through the systematic monitoring of timely activities is fundamental in achieving and transcending the end-goal (‘We went beyond the task’) (Hirst, Van Knippenberg, & Zhou, 2009). These two variables also presented good inter-item correlations (r=.463) in the subscale (see Table A7). Additionally, ‘Group time management’ is also positively correlated with the ‘Level of imagination’ (r = .435), a term associated with divergent thinking and creativity, in related literature too. Specifically, daily planning, confidence of long-term planning, total time-management and perceived control of time and tenacity, are traits of creative individuals or teams that...
regulate their practice in aim of innovative performances (Darini, Pazhouhesh, & Moshiri, 2011; Zampetakis, Bouranta, & Moustakis, 2010).

Finally, existing research posits that ‘Emotional expression’ is closely linked to regulated learning, due to its significance in the orientation and commitment of individuals or teams, towards an end-goal (Prem et al., 2017). Sound socio-emotional workspaces have the capability to promote creativity, by cultivating feelings of trust and inter-connectedness amongst participants. Reversely, negative environments, with a restrictive and distrustful feel, can impede the levels of emotional expression, natural communication, experimentation, and can subsequently lead to poor creative outcomes (Valiente et al., 2012). ‘Emotional expression’ has a relatively low but positive correlation with achievement (‘Boundaries Stretched’) in this subscale (see Table A7).

Significance of findings in HCI

Recently, a group of 32 HCI experts have identified and investigated the seven grand challenges that emerged from current and forthcoming technological and societal demands, which HCI is anticipated to address today (Stephanidis et al., 2019). Creativity and Learning combined, were one of the areas identified. Specifically, their work stressed the need to first understand and then cultivate the learning and transfer of creativity (particularly in CSCL and CSCW settings), in an effort to bring diverse skillsets together using technology, for the development of innovative products that have real-world impact. We agree with this assertion and add that in order to promote creativity in learning, we should also have the right tools at our disposal, that can readily frame it, particularly within real situated settings. We posit that the ASCC
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counts one such tool, which has literally been absent from literature up to now. Below we analyze the significance and contribution of each resulting subscale from our analysis, through an HCI lens.

_Synergistic social collaboration._ Inventivity, as a product of collaboration in HCI teams needs to be adequately measured (Wong, Kotze, Read, Bannon, & Hvannberg, 2007). This subscale aligns well with this HCI objective. It sees learning itself as a creative process, one that uses and customizes existing knowledge to generate new knowledge through communication and social interaction. It therefore places prior domain-level knowledge and the understanding of others’ knowledge, as prerequisites of creative collaboration in teams. This agrees with HCI research, which also sees adequate prior knowledge as a key requirement for the design and evaluation stages in user-centered processes (Culén, 2015; Glăveanu, Ness, Wasson, & Lubart, 2019).

Additionally, over the recent years, HCI has been increasingly concerned with dimensions of affect and emotions that occur in the communication and work processes of teams, as well as in their exchanges with the technology that supports them (Hassenzahl, 2004; Heuer & Stein, 2019; Sanches et al., 2019). The importance of contextual factors (physical, social, technical) or what Rhodes (1961) labeled as ‘Press’ in his creativity framework, in generating a safe and supportive setting for team interaction, is prominent in recent creativity-oriented HCI research (Beckhaus, 2006; Candy, 2013; Hoffmann, 2016). It is also well understood, that to capture this wide range of affective factors, predictive or objective measures should be replaced by methods that gauge for the real situated experiences of people, during or following their interactions. These could be observations, interviews and questionnaires (Candy, 2013; Glăveanu et al., 2019). We believe that all of the resulting subscales of the ASCC, support this direction and constitute the means to achieve this. In line with the overall
scale’s attention to affective factors in creative team activity, this subscale specifically investigates perceptions of trust and safety (trust, safe atmosphere) that are critical in the sharing of knowledge, particularly early on in the project cycle (i.e. the ideation phase). It also agrees well with relevant HCI work which focuses on the factor of interest - often used interchangeably with engagement and motivation – as crucial for creativity (Deterding, 2012; Peters, Calvo, & Ryan, 2018). The subscale refers to interest both at the individual level, as well from the aspect of the technology systems that can stimulate and sustain it in collaborative teams.

The subscale also confirms previous usability-related findings that associate interest with better learning and increased tendencies for higher achievements (orientation towards success) (Zaharias, 2009). It thus provides a well-rounded approach to understanding affective factors in teamwork, which is highly relevant and useful for framing the creative collaboration of teams in HCI fields.

Distributed creativity. Corresponding to the rationale of creativity as one of HCI’s grand challenges (Stephanidis et al., 2019), the ‘Distributed creativity’ subscale focuses on understanding the ways in which divergent ideas (divergent thinking) and novel results (stretching problem boundaries) can emerge from the collective efforts of co-present and remote teams. Amongst others, it pays attention to externalizations, as means of effective communication and as critical components in the design and evaluation stages. Artefacts such as conceptual designs, rapid prototypes, user flows and sitemaps, are fundamental in human-centered design procedures and should receive specific attention in the investigation of creativity in HCI teams (Culén, 2015).

The subscale also aligns well with the HCI focus on creativity support tools (CSTs) (Cherry & Latulipe, 2014). It examines how such tools can mediate team presence (co-presence) in remote locations and facilitate phenomena that are inherent in
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c\co-located\settings, such as the \management of time pressure, disagreement\ and \tension\). In moderate levels, these are reported as positive indicators of \interest\ and can improve negotiation and problem-solving skills, thus enhancing the creative collaboration of teams in the HCI domain (deChambeau, 2017).

\textit{Time Regulation and Achievement}. This subscale places predominant emphasis on the measure of both individual and collective \textit{time-management} - a key component of learning regulation – which combined with freedom of \textit{emotional expression} can significantly impact the level of \textit{achievement} in teams (stretching boundaries) (Pintrich, 2004; Wolters, Won, & Hussain, 2017; Wong et al., 2007).

All these variables are practically relevant in any domain but have elevated significance in an HCI context. The concepts of \textit{time} and \textit{regulation} are central in information technology, UX design and software development, since these are highly collaborative, inherently inter-disciplinary and difficult to manage (Talone, Basavaraj, & Wisniewski, 2017). Over the recent years, product development in these fields has often been the result of distributed teamwork, giving rise to phenomena such as - for instance - the ‘global software development’ (GSD) model, which can reportedly minimize costs and achieve better deliverable quality by utilizing diverse expertise in remote settings (Chadli et al., 2016; Niazi et al., 2013).

Development teams, especially in such distributed environments, are required to apply rigorous techniques and methods to prioritize and monitor self and team-tasks, in order to timely deliver products (Alomar, Almobarak, Alkoblan, Alhozaimy, & Alharbi, 2016). The importance of \textit{time-management}, has also given rise to a genre of software project management tools, built purposely to target the abilities, requirements and limitations of people in the field. Further, aptitude of time regulation, both on an
individual and a collective level, is considered a competitive skill for graduates transitioning into the information technology industries today.

As creative processes and innovative results rely greatly on time management and related variables, we deduce that this subscale makes a meaningful contribution to HCI, through the measuring of how they are perceived by collaborative teams.

**Conclusion**

Recent HCI research denotes that creativity is vital in learning and should be “pursued in the context of current and future education curricula” (Stephanidis et al., 2019), whether these fall under the artistic or scientific disciplines. However, HCI reportedly still falls short of placing the promotion of creative thinking and inventivity at the top of its priority list (Culén, 2015). We propose it has a lot to gain from methods that transcend its disciplinary boundaries and methods, to measure the real situated perceptions of the people involved.

An instrument with psychometric properties measuring specific dimensions of creative collaboration is important in the community’s strive to promote creativity in education, especially in the Design, HCI and Engineering domains. Creativity in these fields is critical, as they are predominantly problem-oriented, human-centered, experimentative and collaborative, aiming towards the development of novel, usable and safe products for the end-user, all of which are constitutive dimensions of creativity.

In this study we examined the properties of an existing instrument, namely, the Assessment Scale for Creative Collaboration (ASCC), by a) determining its subscale structure and its internal consistency reliability and b) analyzing the conceptual relationships amongst their items and analyzing their significance in the HCI domain. Factor analysis produced a three-factor structure (21 items), namely, ‘Synergistic Social
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Collaboration’ (9 items), ‘Distributed Creativity’ (7 items), and ‘Time Regulation and Achievement’ (5 items), all with acceptable reliability scores. Future improvements involve the employment of a Confirmatory Factor Analysis (Briggs & Cheek, 1986; Netemeyer et al., 2003) to provide additional validity to the ASCC instrument.

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https://doi.org/10.1023/A:1024409732742


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# Appendix A

## Table A1

ASCC Principal Axis Analysis with Oblimin Rotation extracted Eigenvalues, Mean & Percentile Data Eigenvalues

<table>
<thead>
<tr>
<th>Factor</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squ Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
</tr>
<tr>
<td>1</td>
<td>9,084</td>
<td>36,336</td>
</tr>
<tr>
<td>2</td>
<td>1,672</td>
<td>6,687</td>
</tr>
<tr>
<td>3</td>
<td>1,065</td>
<td>4,260</td>
</tr>
</tbody>
</table>
### Table A2

Principal Axis Factor Analysis with Oblimin Rotation – factor labels & items, loadings, deletions and retentions

<table>
<thead>
<tr>
<th>Factor</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.930</td>
<td>-.126</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>.850</td>
<td>-.110</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>.813</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>.787</td>
<td>.106</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>.733</td>
<td>.113</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>.642</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>.602</td>
<td>.313</td>
<td>-.152</td>
</tr>
<tr>
<td>8.</td>
<td>.586</td>
<td>.355</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>.579</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>.498</td>
<td>-.136</td>
<td>.317</td>
</tr>
<tr>
<td>11.</td>
<td>.486</td>
<td>.167</td>
<td>.130</td>
</tr>
<tr>
<td>12.</td>
<td>.630</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
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<td></td>
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<tr>
<td>15.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Rotation converged in 6 iterations.
Reliability Statistics for the ASCC Subscales (N = 236)

<table>
<thead>
<tr>
<th></th>
<th>Cronbach’s alpha</th>
<th>Mean inter-item correlations</th>
<th>SD of inter-item correlations</th>
<th>N of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>.924</td>
<td>.695</td>
<td>0.01</td>
<td>11</td>
</tr>
<tr>
<td>Updated*</td>
<td>.893*</td>
<td>.654*</td>
<td>0.00*</td>
<td>9*</td>
</tr>
<tr>
<td>Factor 2</td>
<td>.778</td>
<td>.505</td>
<td>0.01</td>
<td>7</td>
</tr>
<tr>
<td>Factor 3</td>
<td>.758</td>
<td>.529</td>
<td>0.01</td>
<td>5</td>
</tr>
</tbody>
</table>

* following deletion of items 1 and 3
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## Table A4

Scale dimensions, descriptions and individual items

<table>
<thead>
<tr>
<th>Dimension 1</th>
<th>Synergistic Social Collaboration</th>
<th>Theoretical Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension 1</strong></td>
<td><strong>Synergistic Social Collaboration</strong></td>
<td><strong>Theoretical Origin</strong></td>
</tr>
<tr>
<td>9-item subscale that measures social collaborative learning and the conceptual variables of interest and emotional factors such as belonging, mutuality and trust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group interest in the task</td>
<td>1. Everyone in our group was interested in the task.</td>
<td>Interest</td>
</tr>
<tr>
<td>Trust between participants</td>
<td>2. My classmates/colleagues in my group trust each other.</td>
<td>Social Collaborative Learning</td>
</tr>
<tr>
<td>Orientation towards the task success</td>
<td>3. Everyone in my group wanted to make a successful product.</td>
<td>Interest</td>
</tr>
<tr>
<td>Safe atmosphere</td>
<td>4. We had a feeling of belonging together.</td>
<td>Social Collaborative Learning</td>
</tr>
<tr>
<td>Communication</td>
<td>5. We were all able to express our ideas, even controversial ones freely.</td>
<td>Creativity</td>
</tr>
<tr>
<td>Discussion of early ideas</td>
<td>6. We were able to share and discuss our early ideas with each other.</td>
<td>Creative Collaboration</td>
</tr>
<tr>
<td>Level of collaboration</td>
<td>7. We understood another’s viewpoints at the start of the project.</td>
<td>Social Collaborative Learning</td>
</tr>
<tr>
<td>Adequate knowledge base</td>
<td>8. Our group had the necessary knowledge to be able to complete our task.</td>
<td>Social Collaborative Learning</td>
</tr>
<tr>
<td>Shared knowledge and goals</td>
<td>9. I had a good idea of what the others in my group knew that is relevant to this activity.</td>
<td>Interest</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension 2</th>
<th>Distributed Creativity</th>
<th>Theoretical Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension 2</strong></td>
<td><strong>Distributed Creativity</strong></td>
<td><strong>Theoretical Origin</strong></td>
</tr>
<tr>
<td>7-item subscale that measures collective divergent thinking and externalization, the degree of tension and the perceived co-presence in distant teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem boundaries stretched or broken</td>
<td>10. We weren’t always certain about how to carry out the task which led us to explore different possibilities.</td>
<td>Creativity</td>
</tr>
<tr>
<td>A degree of disagreement or tension</td>
<td>11. We sometimes disagreed but we discussed our different points of view.</td>
<td>Creativity</td>
</tr>
<tr>
<td>Group-based time pressure</td>
<td>12. My group were pressured to complete in time.</td>
<td>Time Pressure</td>
</tr>
<tr>
<td>Degree of co-presence (formally - text based)</td>
<td>13. We were able to share information with the other group members formally e.g. in a wiki or shared document.</td>
<td>Interest</td>
</tr>
<tr>
<td>Possibilities for externalizing representations</td>
<td>14. We could see or find out what other people knew or were thinking about. For example, we could draw, write or build things on the computer that the other group members could see and/or read</td>
<td>Creativity</td>
</tr>
<tr>
<td>Degree of co-presence (informally - SN)</td>
<td>15. We were able to chat informally with the other group members via text or social networking.</td>
<td>Interest</td>
</tr>
<tr>
<td>Level of divergent thinking</td>
<td>16. My group generated different and novel ideas in response to the task.</td>
<td>Creativity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension 3</th>
<th>Time Regulation and Achievement</th>
<th>Theoretical Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension 3</strong></td>
<td><strong>Time Regulation and Achievement</strong></td>
<td><strong>Theoretical Origin</strong></td>
</tr>
<tr>
<td>5-item subscale that measures the degree of individual and collective time-management as components of learning regulation that link to achievement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stretching boundaries</td>
<td>17. We went beyond the set task.</td>
<td>Creativity</td>
</tr>
<tr>
<td>Group-level time management</td>
<td>18. Our group organized our time for learning well.</td>
<td>Time Management</td>
</tr>
<tr>
<td>Individual time management</td>
<td>19. I organized my time for learning well</td>
<td>Time Management</td>
</tr>
<tr>
<td>Emotional expression</td>
<td>20. The set task/activity enabled us to express our emotions.</td>
<td>Social Collaborative Achievement</td>
</tr>
<tr>
<td>Level of imagination</td>
<td>21. Between us we used a lot of imagination</td>
<td>Creativity</td>
</tr>
</tbody>
</table>
Table A5

Inter-item correlation matrix for subscale 1: ‘Synergistic Social Collaboration’ subscale

<table>
<thead>
<tr>
<th>Adequate knowledge base</th>
<th>Comm.</th>
<th>Discussion of early ideas</th>
<th>Group interest</th>
<th>Shared knowledge &amp; goals</th>
<th>Task success</th>
<th>Trust</th>
<th>Safe atmosphere</th>
<th>Level of collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequate knowledge base</td>
<td>1.000</td>
<td>.295</td>
<td>.460</td>
<td>.550</td>
<td>.421</td>
<td>.462</td>
<td>.440</td>
<td>.458</td>
</tr>
<tr>
<td>Communication</td>
<td>.295</td>
<td>1.000</td>
<td>.608</td>
<td>.463</td>
<td>.467</td>
<td>.481</td>
<td>.498</td>
<td>.359</td>
</tr>
<tr>
<td>Discussion of early ideas</td>
<td>.460</td>
<td>.608</td>
<td>1.000</td>
<td>.558</td>
<td>.548</td>
<td>.587</td>
<td>.466</td>
<td>.527</td>
</tr>
<tr>
<td>Group interest</td>
<td>.550</td>
<td>.463</td>
<td>.558</td>
<td>1.000</td>
<td>.412</td>
<td>.664</td>
<td>.572</td>
<td>.539</td>
</tr>
<tr>
<td>Shared knowledge &amp; goals</td>
<td>.421</td>
<td>.467</td>
<td>.548</td>
<td>.412</td>
<td>1.000</td>
<td>.500</td>
<td>.477</td>
<td>.401</td>
</tr>
<tr>
<td>Task success</td>
<td>.462</td>
<td>.481</td>
<td>.587</td>
<td>.664</td>
<td>.500</td>
<td>1.000</td>
<td>.563</td>
<td>.552</td>
</tr>
<tr>
<td>Trust</td>
<td>.440</td>
<td>.498</td>
<td>.466</td>
<td>.572</td>
<td>.477</td>
<td>.563</td>
<td>1.000</td>
<td>.573</td>
</tr>
<tr>
<td>Safe atmosphere</td>
<td>.458</td>
<td>.359</td>
<td>.527</td>
<td>.539</td>
<td>.401</td>
<td>.552</td>
<td>.573</td>
<td>1.000</td>
</tr>
<tr>
<td>Level of collaboration</td>
<td>.380</td>
<td>.460</td>
<td>.391</td>
<td>.451</td>
<td>.427</td>
<td>.475</td>
<td>.541</td>
<td>.380</td>
</tr>
</tbody>
</table>
Table A6

Inter-item correlation matrix for subscale 2: 'Distributed Creativity'

<table>
<thead>
<tr>
<th></th>
<th>Degree of co-presence (formal)</th>
<th>Degree of co-presence (informal-SN)</th>
<th>Degree of disagreement or tension</th>
<th>Level of divergent thinking</th>
<th>Externalizing representations</th>
<th>Group-based time pressure</th>
<th>Problem boundaries stretched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of co-presence (formal)</td>
<td>1,000</td>
<td>.544</td>
<td>.357</td>
<td>.312</td>
<td>.366</td>
<td>.212</td>
<td>.223</td>
</tr>
<tr>
<td>Degree of co-presence (informal-SN)</td>
<td>.544</td>
<td>1,000</td>
<td>.354</td>
<td>.392</td>
<td>.473</td>
<td>.140</td>
<td>.233</td>
</tr>
<tr>
<td>Degree of disagreement</td>
<td>.357</td>
<td>.354</td>
<td>1,000</td>
<td>.452</td>
<td>.416</td>
<td>.259</td>
<td>.443</td>
</tr>
<tr>
<td>Level of divergent thinking</td>
<td>.312</td>
<td>.392</td>
<td>.452</td>
<td>1,000</td>
<td>.476</td>
<td>.275</td>
<td>.316</td>
</tr>
<tr>
<td>Externalizing representations</td>
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<td>.473</td>
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### Table A7

Inter-item correlation matrix for subscale 3: ‘Time regulation and Achievement’

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THE ASSESSMENT SCALE FOR CREATIVE COLLABORATION (ASCC) VALIDATION AND RELIABILITY STUDY

About the authors

Aekaterini Mavri is a PhD candidate and a full-time member of the special teaching staff at the Department of Multimedia and Graphic Arts at the Cyprus University of Technology. Her research focusses on the role of cross-organizational Communities of Practice on learning in the Design and relevant fields in Higher Education.

Andri Ioannou is an Assistant Professor at the Department of Multimedia and Graphic Arts and Head of the Cyprus Interaction Lab at the Cyprus University of Technology. She is also the Leader of the Interactive Media and Education/Edutainment research group at the Research Center on Interactive Media, Smart Systems and Emerging Technologies (RISE). In her work, she aims to understand the significant supportive and mediating role of technology in promoting learning, communication & collaboration, and social change in varied circumstances and contexts.

Fernando Loizides is a Lecturer (Assistant Prof.) in Computer Science and Informatics at Cardiff University. Fernando’s main area of research lies in Information Interaction, HCI and Digital Libraries and Accessibility. He has a computer science background, which he combines with digital library research to investigate how systems can be enhanced by emerging technologies. He has extensive experience in user testing and project management, both within industry and academia.