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Evaluating the Reliability of a Social Presence Composite Construct for Online Computer Science Degree Programmes

Joshua D. Reichard
Omega Graduate School, & American College of Education, USA, *jreichard@ogs.edu* & *joshua.reichard@ace.edu*

Mishack T. Gumbo
University of South Africa, South Africa, *gumbomt@unisa.ac.za*

As a contribution to ongoing discussions about the implications of social presence for online instruction technology, this study evaluated the reliability and validity of a composite social presence construct in online computer science programmes using archival data from the Computing Research Association's (CRA) Center for Evaluating the Research Pipeline (CERP) Data Buddies Survey. Questions from the survey were aligned to three interdependent subconstructs of social presence proposed by Kreijns et al (2021). Spearman's rank correlation coefficient was used to analyse the relationships between the subconstructs. Cronbach's alpha was used to evaluate the internal consistency and reliability of the subconstructs of social presence, sociability, and social space, as well as the composite construct of social presence. The findings indicate that the social presence construct and its subconstructs are internally consistent and highly reliable, aligned with the CERP survey. Results indicated that the subconstructs are interrelated indicators of the perception of social presence in online computer science programmes. This study contributes to the literature concerning measuring social presence in online learning by providing a reliable and valid construct that can be used to assess the construct using different permutations of analysis on the CERP dataset.

Keywords: social presence, sociability, online learning, computer science education, learning

INTRODUCTION

Attrition in computer science programmes is a global problem (Bengasai & Pocock, 2021) and a validated social presence construct may help educators improve retention in online degree programmes. Numerous studies in the literature suggest that low pass rates, low student satisfaction, and high attrition in science, technology, engineering, and mathematics (STEM) fields are "the most significant problems" (Zahedi et al., 2020, p. 1) facing related industries (Whitcomb & Singh, 2021; Ajoodha et al., 2020; Lopez & Hassoun, 2022). STEM education presents unique challenges and demands, particularly for minority and underrepresented students, which can contribute to higher

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attrition rates in computer science programmes. For example, Whitcomb et al. (2021) discussed the structural inequities marginalised students face in higher education and the challenges to creating an equitable and inclusive learning environment that takes advantage of student assets and promotes a high sense of belonging. Further, Razail (2021) found alignment between social cognitive and self-determination theories, loosely related to social presence theory, influence students' choices toward STEM careers.

Computer science degree programmes have transitioned to online platforms like other academic disciplines. However, while online learning is convenient and accessible, pertinent questions remain about the qualitative aspects of the online learning experience, particularly in how students perceive and navigate the social dimensions of online environments. The concept of "social presence" in online environments has thus gained traction, drawing the attention of educators and researchers alike. Understanding the dimensions of social presence, particularly in fields like computer science, can enhance online education's efficacy and foster a more enriching learning environment.

In computer-mediated communication (CMC), social presence is a thoroughly researched concept, yet remains elusive and contested among researchers. In online learning, social presence is a theoretical construct that demands continued validation, as called for by seminal scholars in the field (Kreijns et al., 2021; Lowenthal & Snelson, 2017; Kerhwald, 2008). Scholars who attempt to define and measure social presence have suggested that high degrees of perceived social presence are related to student satisfaction, success, and retention (Moallem, 2015; Kerhwald, 2008). The concept has been applied to all forms of telecommunications, especially to computer-based education and online learning (Poth, 2018; Mykota, 2017; Lowenthal & Snelson, 2017; Kerhwald, 2008). However, the concept (and its interrelated issues in online learning) has not been explicitly examined among undergraduate students who have studied computer science online (Chiyaka et al., 2018).

The novel contribution of this study is twofold: it presents a new way of assessing social presence using Kreijns et al.'s theoretical framework and it applies it specifically to online computer science education, where the problems of attrition and exclusion of marginalised students are most keenly felt. This study attempted to evaluate the internal validity of factors that define the social presence construct specifically in online computer science programmes.

The research question was: *What relationship exists between the subconstructs of social presence, sociability, and social space among perceptions of students who have studied computer science online according to aligned items on the CERP instrument?*

Three subconstructs of social presence were abstracted, aligned, and tested for statistically significant correlation using ex-post-facto data from a survey developed by the Computing Research Association's (CRA) Center for Evaluating the Research Pipeline (CERP) called "Data Buddies." Although data were from an instrument not intended initially to measure social presence, they may offer a unique perspective on debates concerning its definition and measurement (Kreijns et al., 2021; Kerhwald, 2008).

Literature Context

As a theoretical construct, social presence is a psychologically unique phenomenon whereby people perceive others as physically 'real' while interacting using computer-mediated communications tools and other electronic platforms. Although the definition of the concept is contested, the definition provided by Kreijns et al. (2021) guided this study. As a composite construct, social presence is the interrelated and inseparable subconstructs of social presence, sociability, and social space (Kreijns et al., 2021, p. 163).

In *IJI* Volume 13, Al-dheleai & Tasir (2020) found that several subconstructs and patterns of online social presence (OSP), except for intimacy, correlate significantly with improved academic performance in a Master of Education programme. Students perceive more social presence when instructors respect and encourage them, share information, and engage in open discussions. The findings of Al-dheleai and Tasir suggest that fostering a sense of social presence through respectful communication and information sharing positively affects students' academic performance in both traditional and online learning environments.

While this study focuses on the problem in the context of the United States, attrition in computer science and related fields is a global problem. Attrition among science students, especially in computer science, is a persistent and perennial problem in online degree programmes (Bengasai & Pocock, 2021; Lopez & Hassoun, 2022; Ajoodha et al., 2020). Therefore, student retention, the antidote to attrition, concerns higher education institutions globally (Bengasai & Pocock, 2021, p. 1). If measuring and improving social presence in online degree programmes can improve retention, this study offers insights into both the problem and the solution.

This study is grounded in the social presence theory. According to Kreijns et al. (2021), social presence comprises three interrelated and irreducible subconstructs: social presence, sociability, and social space. Social presence refers to the degree to which learners perceive others as "real" and their learning environment as having a sense of community. Sociability refers to the frequency of interaction with others in the online learning environment, while social space refers to the sense of belonging in the online learning environment.

Therefore, the conceptual framework used for this study was the interrelated subconstructs proposed by Kreijns et al. (2021) to conceptualise social presence more precisely; these include social presence, sociability, and social space. In fact, Kreijns et al. explicitly emphasize that "researchers concerned with social presence are encouraged to distinguish between the three major variables" (p. 13) they identified in their proposed framework. Applying this conceptual framework to the items on the CERP instrument around the problem of attrition in computer science education is the unique contribution of this study to the broader body of literature. The conceptual framework guides the research design, instrumentation, data analysis, and interpretation of the results.

In like manner, this study examined social presence through a correlational analysis of three subconstructs: social presence, sociability, and social space. Each of these constructs is a unique aspect of the multifaceted nature of social interactions in online educational environments. Using the CERP dataset as the basis for analysis, this study analysed the interdependence of these constructs and their composite relationship with student experiences within undergraduate online computer science programmes in the United States.

METHOD

This study used a correlational research design to examine the relationship between social presence subconstructs as abstracted from the CERP dataset. A correlational research design was considered appropriate to determine whether and how two or more variables are related. In this study, three subconstructs of social presence were assessed: social presence, sociability, and social space. Spearman's rank correlation was used to analyse the relationships between the subconstructs of social presence, sociability, and social space.

Thus, this study aimed to examine the extent of the relationship between the subconstructs of social presence, sociability, and social space among perceptions of students who have studied computer science online according to aligned items on the CERP instrument. A single hypothesis was used to examine whether there was no statistically significant relationship between the subconstructs of social presence, sociability, and social space among perceptions of students who studied computer science online according to aligned items on the CERP instrument. The hypothesis was as follows:

- H1: A statistically significant relationship exists between the subconstructs of social presence, sociability, and social space among perceptions of students who studied computer science online according to aligned items on the CERP instrument.

The CERP instrument was funded by the National Science Foundation (NSF) in the United States, under Grant Numbers CNS-1246649, CNS 1840724, DUE-1431112, DUE 1821136 (CRA, 2022, para. 6). The CERP survey includes questions regarding students' "educational experiences, confidence, attitudes, and career goals" in computer science degree programmes (Lewis et al., 2021, p. 136).

The data are valid insofar as they are part of a nationalised and government-funded instrument developed to understand computer science education programmes. This study utilised an existing dataset based on the CERP Data Buddies survey. Data are made publicly available to researchers upon request. The survey is administered annually to more than 140 participating institutions (Lewis et al., 2021; Wright & Tamer, 2019). The CERP survey is designed to measure "insights into student attrition and retention" (CRA, 2022, para. 2). Both the NSF and CRA encourage researchers to utilise the data to enhance diversity and inclusion in computing education (CRA, 2022).

Kreijns et al. (2014) note that any instrument seeking to measure social presence "should focus on the measurement of how group members perceive 'realness' of the

other" (p. 9). This study does not attempt to create or validate a new instrument to measure social presence. Rather, the theoretical and conceptual frameworks are aligned to data from the CERP instrument to formulate measurable variables related to social presence theory.

In the conceptual framework, the three subconstructs constitute a composite construct of social presence because each is interrelated with the other and cannot be isolated. When integrated holistically, the subconstructs influence establishing and maintaining social interaction in groups in computer-mediated communication (Kreijns et al., 2021, p. 141). However, Kreijns et al. (2021) warn against committing a "jingle fallacy" (Kelley, 1927, pp. 62-65) with the three subconstructs, which occurs when two or more constructs, otherwise conceptually different, are confused or conflated as one in the same construct (p. 141). The three subconstructs were aligned to instrument items independently to mitigate this fallacy, and for posterity, their composite scores were evaluated as a proposed inclusive construct, social presence. As such, "relationships among constructs are expressed in terms of propositions" and "a number of concepts from constructs" (Ngulube et al., 2015, p. 46).

The three subconstructs are defined as follows:

- As a subconstruct, social presence is a psychologically unique phenomenon whereby people perceive others as physically 'real' while interacting using computer-mediated communications tools and other electronic platforms. While the definition of the concept is contested, the definition provided by Kreijns et al. guided this study. As a composite construct, social presence is the interrelated and inseparable subconstructs of social presence, sociability, and social space (Kreijns et al., 2021).
- Sociability is the extent to which computer-mediated communication tools and electronic platforms "allow for the expression of social presence and the experience of it as well as for the emergence of social space" (Kreijns et al., 2021, p. 141). Sociability is a feature of the tool or technological medium itself.
- Social space is a "sense of community, group climate, mutual trust, social identity, and group cohesion" that individuals feel when using CMC tools (Kreijns et al., 2021, p. 163). Social space is a sociological construct.

This study included the following dependent variables: composite social presence score (comprised of social presence, sociability, and social space subscales). The alignment of the three subconstructs of social presence, sociability, and social space to the items on the CERP instrument within the context of Kreijns et al.'s conceptual framework may enhance, though like any social or behavioural science measurement, not guarantee, construct validity; it may, however, support the reliability of the underlying measures (Zumbo & Rupp, 2009, p. 75).

For clarity, it is important to "relate the variables to the specific questions or hypotheses on the instrument" (Creswell, 2018, p. 217). Table 1 is an overview of the theoretical framework aligned to the associated variables and items of the CERP instrument.

Table 1
Alignment of conceptual framework and abstracted variables

Variable	CERP Items
Subconstruct: Social Presence	#80b-d,f; #76a,d
Subconstruct: Sociability	#50b-d
Subconstruct: Social Space	#76b,e; #49a

Most of the subitems on the CERP survey are on an interval scale of "Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree," where "Strongly disagree"=1 and "Strongly agree"=5. Next, subitems for social presence and its subconstructs were grouped, and the total possible number of points was divided by the number of subitems to produce a final scale of 1-5 for each subconstruct. Table 2 is a summary of the transposed scales for each subconstruct variable.

Table 2
CERP items and transposed scales

Variable	CERP Items	Scale	Possible Total	Transposed Scale
Subconstruct: Social Presence	#80b-d,f; #76a,d	1-5	30	30 / 6 = 5
Subconstruct: Sociability	#50b-d	1-5	15	15 / 3 = 5
Subconstruct: Social Space	#76b,e; #49a	1-5	15	15 / 3 = 5
Construct: Composite Social Presence	12 sub-items, totalled	1-5	60	60 / 12 = 5

In addition to measuring the correlation of the three subconstructs, this study sought to address threats to construct validity by incorporating a test of internal correlation between the constructs as part of this study. Calculations of Cronbach's (1951) alpha was also applied to the specific items from the CERP instrument for each subconstruct and reported as part of testing the hypothesis. The closer the reliability coefficient of Cronbach's alpha is to 1, the stronger the internal consistency of the items on the instrument.

This study did not directly involve human participants using publicly available archival data from the CERP survey. Variables from data points aligned with theoretical and conceptual frameworks were tested using appropriate correlational statistical procedures.

The sample comprised 2,003 undergraduate computing students who were members of the CRA in the United States. Of these, 1,669 cases were included in the analysis of social presence, 1,970 cases were included in the analysis of sociability, and 1,758 cases were included in the analysis of social space. The mean age of the participants was 21.4 years (SD = 4.4), and most were male (72.4%). In addition, the participants were from various ethnic backgrounds, with 64.1% identifying as White, 11.5% as Asian, and 7.9% as Hispanic or Latino.

FINDINGS

Descriptive statistics, including means and standard deviations, were computed to characterise the sample and the study variables. Spearman's rank correlation procedure was used to analyse the relationships between the subconstructs of social presence, sociability, and social space.

The subconstructs of social presence, sociability, and social space were statistically significantly related, with moderate correlations. The composite construct of social presence and its subconstructs were internally consistent and highly reliable. Cronbach's alpha coefficients were .817 for the composite social presence construct, .853 for the social presence subconstruct, .540 for the sociability subconstruct, and .700 for the social space subconstruct. These reliability findings support the validity of the constructs used to assess social presence according to aligned items on the CERP instrument.

The results also revealed statistically significant correlations between the social presence subconstruct, sociability subconstruct, and social space subconstruct. The social presence subconstruct was positively correlated with the sociability subconstruct ($r = .202$, $p < .01$) and the social space subconstruct ($r = .429$, $p < .01$). The sociability subconstruct was positively correlated with the social space subconstruct ($r = .139$, $p < .01$).

Moreover, Cronbach's alpha was applied to each social presence subconstruct and the composite construct to evaluate internal reliability. Cronbach's (1951) alpha measures the internal consistency of a set of constructs. Cronbach's alpha is "the average correlation among all possible pairs of items, adjusting for the number of items" (Hanover College, 2016). Like a correlation coefficient, Cronbach's yields a value ranging from 0 to 1. Values closer to 1 indicate higher reliability. Ideally, constructs should have an alpha score greater than 0.7 to indicate strong internal consistency. Cronbach's alpha was computed in SPSS using the Reliability Analysis feature. Variables for each subconstruct and the composite construct were selected to analyze each construct. The next subsections present the reliability findings for each subconstruct and the composite social presence construct.

Social Presence Subconstruct

The social presence subconstruct was tested for internal consistency. A total of 2003 cases were considered for the analysis; 1669 cases were included, and 334 cases were excluded (see Tables 3 and 4).

Table 3
Case processing summary for social presence subconstruct

		N	%
Cases	Valid	1,669	83.3
	Excluded [a]	334	16.7
	Total	2,003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 4
Reliability statistics for social presence subconstruct

Cronbach's Alpha	N of Items
.853	6

Based on the computed Cronbach's alpha of .853, the social presence subconstruct can be considered internally consistent and highly reliable.

Sociability Subconstruct

The sociability subconstruct was tested for internal consistency. 2,003 cases were considered for the analysis; 1,970 cases were included, and 33 cases were excluded (see Tables 5 and 6).

Table 5
Case processing summary for sociability subconstruct

		N	%
Cases	Valid	1,970	98.4
	Excluded [a]	33	1.6
	Total	2,003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 6
Reliability statistics for sociability subconstruct

Cronbach's Alpha	N of Items
.540	3

Based on the computed Cronbach's alpha of .540, the sociability subconstruct can be considered minimally internally consistent and moderately reliable.

Social Space Subconstruct

The social space subconstruct was tested for internal consistency. 2,003 cases were considered for the analysis; 1,758 cases were included, and 245 cases were excluded (see Tables 7 and 8).

Table 7
Case processing summary for social space subconstruct

		N	%
Cases	Valid	1,758	87.8
	Excluded [a]	245	12.2
	Total	2,003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 8
Reliability statistics for social space subconstruct

Cronbach's Alpha	N of Items
.700	3

Based on the computed Cronbach's alpha of .700, the sociability subconstruct can be considered internally consistent and highly reliable.

Social Presence Construct

Finally, the social construct, which comprised all variables constituting the three subconstructs, was tested for internal consistency. 2,003 cases were considered for the analysis; 1,646 cases were included, and 357 cases were excluded (see Tables 9 and 10).

Table 9
Case processing summary for social presence construct

		N	%
Cases	Valid	1,646	82.2
	Excluded [a]	357	17.8
	Total	2,003	100.0

a. Listwise deletion based on all variables in the procedure.

Table 10
Reliability statistics for social presence construct

Cronbach's Alpha	N of Items
.817	12

Based on the computed Cronbach's alpha of .817, the social presence construct can be considered internally consistent and highly reliable.

Reliability and Validity

This study's construct validity is rooted in the construct and subconstruct variables being based on a well-established, though not psychometrically validated, survey instrument designed to measure student attrition and retention in computing programmes (DeVellis, 2016). The constructs and subconstructs also align with the conceptual framework and research questions. The composite construct of social presence is based on three interrelated and irreducible subconstructs. Multiple questions were used for the social presence construct and related subconstructs. Multiple questions with multiple data points may have strengthened the construct validity of these measures.

Content validity is also defensible for the same reasons: they were chosen based on their alignment with this study's conceptual framework, research questions, and the CERP survey instrument. Original questions were not created for this study. Only extant data from the CERP Data Buddies dataset were analysed ex-post-facto, meaning the instrument was unmodified.

DISCUSSION

This study contributes to the literature concerning measuring social presence in online learning by providing a comprehensive analysis of the reliability of the social presence construct and its subconstructs. This study applied Cronbach's alpha to each subconstruct and the composite construct of social presence to evaluate internal reliability. The findings indicate that the social presence construct and subconstructs are internally consistent and highly reliable. Specifically, the social presence subconstruct had a Cronbach's alpha of .853, the social space subconstruct had a Cronbach's alpha of

.700, and the sociability subconstruct had a Cronbach's alpha of .540. In addition, the composite social presence construct had a Cronbach's alpha of .817. These reliability findings support the validity of the constructs used to assess social presence according to aligned items on the CERP instrument. This study's reliability analysis provides important insights into measuring social presence in online learning and can contribute to the ongoing development of the theory and practice of online learning (Kreijns et al., 2021; Kerhwald, 2008).

The statistical interrelatedness of the subconstructs (social presence, sociability, and social space) within the perceptions of online computer science students supports the findings of prior literature (Kreijns et al., 2021; Al-dheleai & Tasir, 2020). The subconstructs of social presence, sociability, and social space are all significantly related to each other according to perceptions of students who have studied computer science online according to aligned items on the CERP instrument. Results suggest that these constructs are interrelated collective indicators of the perception of social presence in online learning environments.

The social presence subconstruct was positively correlated with the sociability subconstruct, with a correlation coefficient of 0.202, which is statistically significant at a 2-tailed significance level of < 0.001. Students who reported higher perceptions of social presence may also report higher sociability or a higher frequency of interaction in online undergraduate computer science degree programmes. However, the effect was small.

The social presence subconstruct was also positively correlated with the sociability subconstruct, with a correlation coefficient of 0.429, statistically significant at a 2-tailed significance level of < 0.001. Results indicate that students who perceive others as more "real" may also perceive those environments as having greater social space or a sense of belonging in online undergraduate computer science degree programmes. However, again, the effect was small.

Moreover, the sociability subconstruct was positively correlated with the sociability subconstruct, with a correlation coefficient of 0.139, statistically significant at a 2-tailed significance level of < 0.001. More sociable platforms may foster more perceptions of social space in online undergraduate computer science degree programmes. While all three correlations are statistically significant, the strength of the relationships between the variables was moderate. Other factors beyond social presence, sociability, and social space may influence students' experiences in online undergraduate computer science degree programmes. However, it's important to note that while these correlations were statistically significant, their effect sizes were relatively small. The potential influence of additional factors beyond social presence, sociability, and social space on students' experiences in online undergraduate computer science programmes, is consistent with the broader literature (Whitcomb et al., 2021; Razail, 2021; Kreijns et al., 2021).

Furthermore, the observed small effect sizes in these correlations emphasize the nuanced nature of social presence. While social presence, sociability, and social space are statistically interrelated, they represent only one aspect of the broader factors influencing student engagement and success in online computer science programmes

(Whitcomb et al., 2021). Attrition and retention in STEM fields, specifically in computer science programmes, are global concerns highlighted in the literature (Bengasai & Pocock, 2021; Lopez & Hassoun, 2022). While social presence plays a role in enhancing the online learning experience, it is clear that a combination of structural, educational, and sociocultural factors shapes students' trajectories in these programmes.

The implications of this study are that the subconstructs of social presence, sociability, and social space can be assessed in online undergraduate computer science programmes using data from the CERP instrument. These constructs, while interrelated, may also function independently, which can be assessed to improve online course design and student engagement. The findings suggest additional validated instruments are needed to evaluate such constructs accurately. However, the study's focus on a specific demographic and use of a non-validated survey tool indicates that its findings should be applied within the bounds of its limitations.

CONCLUSION

This study contributes to the literature by evaluating the reliability of a construct to assess social presence in online learning environments. Social presence, sociability, and social space are valid yet independently functioning factors in enhancing online learning experiences, particularly in computer science education. Future studies should aim for more validated instruments to assess these constructs in other educational contexts.

As noted by Tu & McIsaac (2002), "reliable measures are critical for developing an accurate picture of the construct being assessed and can increase the validity of the results obtained" (p. 192). Therefore, the findings of this study can inform future research on social presence in online learning by providing a reliable construct that can be used to assess the construct using different permutations of analysis on the CERP dataset.

Statistically significant correlations among the subconstructs suggest that interactions may affect students' perceptions and experiences in online education, including academic performance (Al-dheleai & Tasir, 2020). However, while the correlations between the subconstructs are statistically significant, they are not particularly strong. When designing and evaluating online learning environments, a holistic understanding, where not only one, but all aspects of social presence should be considered.

The three subconstructs proposed by Kreijns et al. (2021), which are social presence, sociability, and social space, were aligned to items on the CERP Data Buddies survey and analysed for internal validity and reliability. Statistically significant, albeit moderate, correlations among these constructs affirm their conceptually interrelated and interdependent nature. The findings suggest that while the CERP may be a reliable tool for certain constructs, it may benefit from further refinement. Especially given the lower reliability of the sociability subconstruct, future studies may consider exploring alternative ways to measure sociability in online environments.

The results derived from the CERP dataset indicate strong reliability for social presence and social space constructs. However, the sociability subconstruct presents an area that requires further examination and refinement in future research. This study should provoke future research to examine other influencing variables or investigate a broader range of participants and contexts within or beyond the CERP dataset. Given the specific focus on undergraduate computing students who are members of the CRA in the United States, it would be beneficial to replicate the study with different populations to test the generalizability of the findings. Subsequent studies should examine other factors, such as technology proficiency, instructional strategies, or even personal attributes like introversion and extroversion, and to see how they interact with the subconstructs of social presence, sociability, and social space.

LIMITATIONS

Several limitations should be considered when interpreting the findings of this study. First, the study utilised secondary data from the CERP survey, which was not designed specifically for this study. The CERP survey has not been validated as a psychometric instrument, and some questions have questionable validity. Data analysed in this study was drawn from a single survey instrument, the CERP, which has not been psychometrically validated as an instrument for measuring social presence in online learning environments. Second, this study focused only on undergraduate computing students in the United States who are members of the CRA, which may limit the generalisation of the findings to other populations or contexts. This limitation may affect the study's validity and limit the generalisability of the findings to other contexts or populations. Third, this study did not investigate potential mediating or moderating variables that may influence the relationships between the subconstructs. Finally, while the correlations between the subconstructs are significant, they are not particularly strong, indicating that an interrelationship exists, but the subconstructs may also operate somewhat independently.

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