Digital competence as a protective factor against gaming addiction in children and adolescents: A cross-sectional study in Hong Kong

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Summary

Background Digital competence can help children and adolescents engage with technology for acquiring new knowledge and for broadening social contact and support, while reducing the risk of inappropriate media use. This study investigated the effects of digital competence on the risk of gaming addiction among children and adolescents. We explored whether students with good digital competence were protected from the adverse effects of media use and the risk of gaming addiction.

Methods 1956 students (690 primary and 1266 secondary) completed a digital competence assessment and a self-report questionnaire on their mental health status, use of digital devices, and experiences of cyberbullying. Multiple regression analyses with further mediation and moderation analyses were performed to investigate the association of digital competence with gaming addiction and mental health in children and adolescents.

Findings Regression analyses showed that children and adolescents with better digital competence were less likely to develop gaming addiction ($\beta = -0.144, p < 0.0001$) and experienced less cyberbullying behaviour as perpetrators ($\beta = -0.169, p < 0.0001$) and as victims ($\beta = -0.121, p < 0.0001$). Digital competence was found to mediate the relationship between digital device usage time and gaming addiction.

Interpretation Digital competence is associated with less gaming addiction and could potentially lead to better mental wellbeing by reducing the risks of gaming addiction and cyberbullying. Education that promotes digital competence is essential to maximize the benefits of media use, while reducing the potential adverse effects from the inappropriate use of digital devices.

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Introduction

Technology plays an increasingly large role in today’s world. Children and adolescents are exposed to digital media at a very young age and social media is becoming a big part of their lives. As a result, the influence of media on children has been gaining increasing attention among parents, educators, and healthcare professionals. Overuse of media and increased screen time are known to have detrimental effects on children’s physical and mental health, including the lack of physical exercise, sleep deprivation, and decreased face-to-face social interactions.1

Although video gaming and internet surfing have become popular recreational activities for children and adolescents, there are growing concerns about gaming
Articles

Research in Context

Evidence before this study
We searched PubMed, Web of Science and Google Scholar until 1st August 2021, for studies regarding the impact of digital competence on mental health and/or gaming addiction. The search terms were digital competence, game or gaming disorder, gaming or internet addiction or mental health or mental wellbeing AND children or adolescents, primary school or secondary school students. Studies on the association between digital competence and gaming addiction in children are lacking, though there were limited studies suggesting digital literacy could be beneficial for adolescents to achieve better health and well-being.

Added value of this study
This study is one of the first to demonstrate that better digital competence is associated with a lower risk of gaming addiction, which could potentially lead to better mental wellbeing in children and adolescents.

Implication of all the available evidence
Our study highlighted the importance of digital competence in children and adolescents. We demonstrated that the use of digital device is not ‘inherently bad’ for children’s mental health, digital competence is associated with lower risk of gaming addiction and can promote digital wellness in our younger generation.

and internet addictions and the related physical and mental health risks. According to a recent parent survey in the United Kingdom, 53% of parents were worried about their children’s use of technology, which was their greatest concern above drug and alcohol use, school performance, or sexual identity.6 Problematic internet use is increasingly being recognised as a public health concern.

Mainland China is reported to have one of the highest prevalence rates of internet/gaming addiction among adolescents.3,4 However, the prevalence of internet/gaming addiction is less clear for younger school-aged children. In addition, studies have shown that children or adolescents with gaming addiction are more likely to develop physical health problems such as obesity and insomnia.6,7 They are also more likely to exhibit aggression,8 impulsive behaviours, and psychiatric symptoms such as obsessive-compulsive disorder.9 Children and adolescents with gaming addiction are prone to risky online behaviours such as cyberbullying, in which the perpetrator causes malicious, repetitive, and hostile harm to individuals or groups via the internet.10 Cyberbullying can lead to serious mental health consequences such as suicide attempts.11 There are several intervention programs that target children and adolescents with signs of gaming addiction or risky online behaviours, although their effectiveness can vary.12-15 Hence, there is a need for effective interventions to prevent gaming addiction and cyberbullying in young children and adolescents. This study investigated whether children with good digital competence can protect against gaming addiction and risky online behaviours such as cyberbullying. Educating future generations with good digital competence could be a relatively easy way to prevent gaming addiction in children and adolescents.

Existing literature often focuses on how the excessive use of digital devices can negatively affect the health and mental wellbeing of children and adolescents. On the other hand, appropriate media use can also be beneficial for school-aged children and adolescents, enabling them to acquire new knowledge and providing opportunities for social interaction and peer support. The American Academy of Paediatrics (AAP) recommends that media use in school-aged children and adolescents should be balanced with other healthy behaviours.16 Parents can find it very challenging to guide their children on the appropriate use of media. Many parents and educators believe that digital education, the promotion of online safety, and the prevention of online harms should be crucial parts of the school curriculum across all age groups.17 In the modern digital age, it is impractical and unrealistic to ban the use of media in children and adolescents. Therefore, digital competence is essential for the appropriate use of digital media.

Various labels associated with the term “literacy” have been used in assessment frameworks and studies to describe the knowledge, skills, and attitudes deemed necessary to succeed in the digital era. These labels include “computer literacy”, “information literacy”, “information and communication technology (ICT) literacy”, or “digital literacy”, among others.16,18 Despite these diverse labels, there is a distinct set of competences converging around the retrieval, processing, communication, and production of information and content used in ICT.17 To avoid confusion, here, we use the more comprehensive term “digital competence”, which “can be broadly defined as the confident, critical, and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion, and/or participation in society”.19 Digital competence can be thought of as a multifaceted competence in the use of digital technology involving several aspects, such as an individual’s ability to evaluate, integrate, and create digital content (including digital information), solve digital problems, as well as communicate and collaborate with others safely and appropriately.20 It encompasses knowledge and skills that enable children and adolescents to use technology wisely and safely. In fact, digital competence is essential for participation in society and social life, as technology become integrated into our
daily lives. It is an important facilitator of success in school and in the workplace, as digital technologies permeate all sectors.21,22 Thus, it is not surprising that several studies have been conducted in the field of education to assess the competent use of digital technologies, including high-profile national and international assessment studies, such as the Australian National Assessment Program for ICT literacy (NAP-ICT)23 and the International Computer and Information Literacy Study (ICILS).24 Although most assessments of digital competence have adopted a multidimensional framework, the empirical findings tend to agree that digital competence can be conceived as a unidimensional measure,25,26 and studies that report different dimensions of digital competence find high correlations among these dimensions.27,28

However, many assessment frameworks of digital competence are limited in identifying and evaluating information (i.e., information literacy) and technical skills.17 Moreover, research has shown that self-reported assessments of digital competence may not be accurate. For example, high school students in Israel and the U.S. were found to have overestimated their digital competence.29,30 In addition, male students tended to self-report higher levels of digital competence than girls,31,32 although performance assessments indicated that girls actually show slightly higher performance.31,33

Besides gender differences, other factors such as socioeconomic status (SES) and age can affect digital competence. A meta-analysis of empirical studies found a small overall correlation between digital competence and SES.34 Although only a few studies have examined digital competence across different age cohorts, some empirical studies indicated that older students, on average, are more digitally competent than younger students, but with significant overlaps in performance.35,36 A range of studies have been conducted to examine the associations between digital competence and the possible outcomes.

Nevertheless, there is little research on whether better digital competence can improve children’s health and mental wellbeing by reducing the risk of internet/gaming disorders37 and preventing poor online behaviour such as cyberbullying. Previous studies have shown that digital competence can have both positive and negative effects on internet-related disorders.38,39 However, the majority of these studies were performed on secondary school students aged 12 or above. In contrast, research examining the effects of digital competence in younger school-aged children between 6 and 12 is lacking.

In addition, the majority of the digital competence assessment scales are based on self-report questionnaires, which are prone to reporting and recall bias. In order to address these research gaps, our team devised a digital competence assessment scale based on the direct performance of school-aged children and adolescents.40 Using our newly validated digital competence assessment scale, this study aims to demonstrate how digital competence impacts the mental health of children and adolescents, and to explore whether good digital competence is associated with reducing the harmful effects of media use, while enhancing its positive effects on children’s mental development.

Methods

Participants

A total of 18 primary schools and 14 secondary schools were randomly selected from four districts in Hong Kong (out of a total of 18 districts) with different socioeconomic backgrounds. Two classes of students in the selected grade levels were sampled in each participating school, although some schools included more than two classes of students in some grades. The total number of participating classes in the study was 95. Overall, 1956 students (690 in Primary 3 with an age range of 7-11 and 1266 in either Secondary 1 [7th grade equivalent] or Secondary 3 [9th grade equivalent] with an age range of 11-18) participated in this cross-sectional study. Informed consent was obtained from parents and students (assent for primary students) before the start of the study.

All students completed a self-report questionnaire on their psychological health, lifestyle habits, and social experiences. Students also filled in a performance assessment testing their digital competence. Secondary school students further participated in an assessment testing their collaborative problem solving ability. The survey and assessments were delivered to the participating classes through desktop computers, notebooks, or tablets, depending on the schools’ preferences.

In total, the student response rate was 79%. Reasons for non-participation were parental refusal to consent, failure to return the consent form, or consenting students absent on the day of data collection. Students who did not complete the relevant instruments or whose responses indicated a lack of validity were also excluded from the analysis.

This study was approved by the Human Research Ethics Committee (HREC approval number: EA1604935) of the University of Hong Kong.

Assessment. The digital competence assessment consisted of a constrained item format with interactive items mimicking realistic everyday scenarios that students might encounter in their daily lives. Age-appropriate items measuring students’ competence in computer use in five areas were developed and piloted prior to the data collection.40 The five computer use areas were based on the Digital Competence Framework (DigComp 2.1) developed by the European Commission: 1) Information and data literacy, 2) Communication and collaboration, 3) Digital content creation, 4) Safety, and
which consists of 12 questions assessing the severity of mental health problems in the past 4 weeks. To measure the level of students’ gaming addiction, the Internet Gaming Disorder Scale (IGD) was adopted, which consists of nine items scored on a 5-point Likert scale based on the nine criteria of the Internet Gaming Disorder in DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, 5th Edition). Higher scores in the above two scales indicated worse conditions in terms of the students’ mental health and addiction issues.

For the assessment of lifestyle habits, students were asked to estimate the time spent sleeping and using electronic devices for leisure, including smartphones and tablets. For experiences related to cyberbullying, an instrument consisting of 12 questions was used to measure students’ experience of cyberbullying as the perpetrator (e.g., sent or forwarded a hurtful message electronically to someone) or as the victim (e.g., had an embarrassing photo or video posted or reposted online). This instrument has been previously validated in other cultural contexts. Participants’ overall responses are summarized in Table 1.

Statistical Analysis. Partial correlation was performed to examine the relationship between digital competence and gaming addiction, as well as other variables of interest including mental health status (GHQ score), time spent on electronic devices, cyberbullying, cybervictimization, cognitive CPS score, and social CPS score, controlling for gender and participants’ SES. The SES index was estimated from parents’ education level using a principal component analysis. The mean SES score of each school was calculated to estimate the SES of participants whose parents’ education level was missing. Moderated multiple regression was performed to further explore the relationships between digital competence, gaming addiction, cyberbullying, and cybervictimization. Hierarchical multiple regression was conducted to examine the direct effects (DE), total effect (TE) and indirect effects (mediation) of children’s electronic device usage time on gaming addiction and their mental health status. For the regression, the reported mental health status was reverse coded from the GHQ scale. All variables in the moderation and mediation analyses were transformed to z-scores to reduce the multicollinearity between these variables and the interaction variables. Gender and SES were controlled as additional covariates in all models. All statistics were performed by IBM SPSS (Version 27) with 5% alpha levels. Process Macro (v 3.53) for SPSS was used to perform the moderation and mediation analyses.

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design, data collection, data analysis, data interpretation or manuscript preparation.

**Results**

Table 1 summarizes the demographic characteristics of participants. The overall prevalence of gaming addiction was 7.3% (Primary: 8.0%; Secondary: 6.6%) according to the cut-off score (32) suggested by Qin et al. for the Chinese context. Table 2 illustrates the prevalence of gaming addiction according to digital device usage time. Primary and secondary students who used digital devices for more than 3 hours per day had a significantly higher prevalence of gaming addiction ($X^2[3,1865] = 19.91, p < 0.001$).

The correlation analyses showed that digital competence was negatively associated with gaming addiction and cyberbullying experiences, whereas gaming addiction was positively associated with cyberbullying experiences and the GHQ score, suggesting worse mental health (Table 3). The results of the supplementary sensitivity analysis in secondary school children after controlling for age, cognitive and social CPS (Table S1 & S2) were generally consistent with the primary analysis, suggesting that adding age as a confounder had no major impact on the conclusion.

To explore the role of students’ digital competence on gaming addiction and social experiences, we performed a multiple moderated regression analysis, which revealed that digital competence was negatively
associated with the level of gaming addiction after controlling for gender and SES ($\beta = -0.144$, $p < 0.0001$). There was a significant interaction effect of digital competence with children's education level on gaming addiction (F [1,1802] = 16.42, $p < 0.0001$). After including the interaction term, the effect size ($R^2$) of the regression model changed from 6.7% to 7.5% ($R^2$ change = 0.8%). Specifically, the association between digital competence and gaming addiction was more pronounced in primary school students ($\beta = -0.368$, $p < 0.0001$) compared with secondary school students ($\beta = -0.117$, $p = 0.0005$) (Figure 1).

Hierarchical multiple regression revealed an association between digital device usage time and mental health status that was mediated by gaming addiction. Digital device usage time was found to be a significant negative predictor of mental health status after controlling for gender and SES ($\beta = -0.24$, $p < 0.0001$; model 1: $R^2 = 4.0\%$). Such effects became non-significant when gaming addiction was included in the model ($\beta = -0.03$, $p = 0.26$; model 2: $R^2 = 9.4\%$; $R^2$ change = 5.4%). The Bootstrap test found a significant negative indirect effect of digital device usage time on mental health status through gaming addiction ($\beta = -0.05$, SE$_{boot} = 0.01$, 95%CI$_{boot} = [-0.06, -0.03]$ after 5000 bootstrap samples). Figure 2 shows the relationship between digital device usage time, gaming addiction, digital competence, and mental health status.

On the other hand, digital competence was negatively associated with cyberbullying ($\beta = -0.169$, $p < 0.0001$) and cybervictimization ($\beta = -0.121$, $p < 0.0001$), as shown in a regression model using cyberbullying and cybervictimization as the outcome variables, digital competence as the predictor, gender and SES as covariates, and gaming addiction as the moderator. There was a significant interaction between digital competence and gaming addiction on cyberbullying (F [1,1779] = 19.62, $p < 0.0001$) and cybervictimization (F [1,1776] = 19.62, $p < 0.0001$), respectively (Figures 3 & 4). For the

**Table 2: Prevalence of gaming addiction according to digital device usage time**

| Time Using Digital Devices for Leisure | Secondary school student | Primary School student | Total |
|---------------------------------------|--------------------------|------------------------|-------|
| Less than 1 hour per day              | 6.9%                     | 5.7%                   | 6.3%  |
| 1-2 hours per day                     | 4%                       | 8.4%                   | 5.6%  |
| 2-3 hours per day                     | 4.2%                     | 9.0%                   | 5.3%  |
| More than 3 hours per day             | 11.7%**                  | 16.4%**                | 12.4%**|

**Table 3: Partial Correlation between variables after controlling for gender and socioeconomic status (SES) index**

| Variables                              | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|----------------------------------------|----|----|----|----|----|----|----|
| 1. Digital Competence                  | —  | —  | —  | —  | —  | —  | —  |
| 2. Gaming Addiction                    | -0.148** | —  | —  | —  | —  | —  | —  |
| 3. GHQ score                           | 0.027 | 0.248** | —  | —  | —  | —  | —  |
| 4. Cybervictimization                  | -0.119** | 0.278** | 0.245** | —  | —  | —  | —  |
| 5. Cyberbullying                       | -0.164** | 0.319** | 0.180** | 0.631** | —  | —  | —  |
| 6. Cognitive CPS                       | 0.400** | -0.083* | -0.012 | 0.029 | -0.012 | —  | —  |
| 7. Social CPS                          | 0.259** | -0.095** | -0.043 | 0.025 | -0.006 | 0.609** | —  |
| 8. Time using electronic devices for leisure | 0.236** | 0.172** | 0.088** | 0.091** | 0.063* | -0.021 | -0.036 |

*p < 0.01

**p < 0.001. Note: Missing values were excluded pairwise. Only secondary school students filled in the GHQ and participated in the CPS assessments (variables 1, 6, and 7).
regression model with cyberbullying as the outcome variable, the effect size ($R^2$) of the regression model changed from 12.0% to 14.6%, with $R^2$ change = 2.6% after adding the interaction term ‘digital competence * gaming addiction’. For the regression model with cybervictimization as the outcome variable, the effect size ($R^2$) of the regression model changed from 8.0% to 9.4%, with $R^2$ change = 1.4% after adding the interaction term ‘digital competence * gaming addiction’. Nevertheless, the relationship between digital competence and cyberbullying was significant only when gaming addiction was high ($\beta = -0.286, p < 0.0001$), but non-significant with medium ($\beta = -0.067, p = 0.0003$) and low ($\beta = 0.050, p = 0.121$) gaming addiction levels. A similar pattern was also observed for the relationship between digital competence and cybervictimization with high ($\beta = -0.203, p < 0.0001$), medium ($\beta = -0.043$, $p = 0.072$), and low ($\beta = -0.04, p = 0.791$) gaming addiction.

**Discussion**

This study is one of the first to demonstrate that higher digital competence is associated with a lower risk of gaming addiction, which could potentially lead to enhanced mental wellbeing in children and adolescents through reducing gaming addiction. Our findings highlight the importance of empowering children and adolescents through digital competence to encourage appropriate media use and reduce the risk of addictive and risky online behaviours.

Prolonged use of digital devices by children or adolescents is a frequent concern of parents. Wong et al.
Gaming addiction is a global problem that universally affects children and adolescents. A recent study reported the prevalence of gaming addiction was 10.3% in students of different ages, which is broadly in agreement with the prevalence of 7.3% in our cohort. Gaming disorder has now been included in the 11th revision of the International Classification of Disease (ICD-11), and is defined as a gaming behaviour of sufficient severity to result in significant functional impairment. Our study found that gaming addiction was associated with poorer GHQ scores in adolescents, indicating poorer mental health. The existing literature also suggests that young people with gaming addiction are prone to affective symptoms such as anxiety, depression, and negative coping styles. Moreover, functional neuroimaging studies suggest that gaming addiction might lead to over-connectivity of the default mode and executive control networks that may lead to psychiatric comorbidity. Besides affective disorders, gaming addiction was also found to be associated with attention-deficit hyperactivity disorders (ADHD). Excessive internet gaming exposure was found to be associated with reduced striatal dopamine D2 receptors, leading to the dysfunction of the dopaminergic system, which is also believed to underlie the pathogenesis of ADHD.

Unfortunately, gaming addiction/gaming disorder is difficult to treat, as medications might be ineffective in managing the addictions. Patients often refuse to take their medication or have poor compliance with behavioural interventions. With the increasing use of digital technologies for gaming, it is essential to teach children and adolescents digital competence to reduce the risk of gaming addiction.

Cyberbullying, which poses a significant threat to children’s mental health and development, can be a result of prolonged internet usage and gaming addiction. Our study findings indicated that digital competence could protect children from cyberbullying behaviours, especially those who are highly addicted to internet gaming. An ecological study involving 24 European countries showed that higher rates of cyberbullying were more likely to lead to a higher incidence of unnatural child deaths. Therefore, teaching digital competence to children and adolescents is critically important and could potentially minimize the long-term adverse physical and mental health outcomes related to prolonged media use.

The majority of the literature on the use of digital devices focuses on the detrimental effects of media use in children and adolescents. However, the appropriate use technology can provide opportunities to learn and to communicate with other children. In addition, our study showed that adolescents with better digital competence had better collaborative problem solving (CPS) skills. Such skills are critical in academic learning and also necessary for daily life. The Programme for International Student Assessment (PISA), which is part of the programme of the Organisation for Economic Cooperation and Development (OECD), defines CPS competency as the capacity of an individual to effectively

Figure 4. Cybervictimization as a function of digital competence at different levels of game addiction after controlling for gender and SES. Low, medium, and high levels of game addiction defined as 1 S.D. below, equal to, and 1 S.D. above the mean level of game addiction, respectively.

**Figure 4.** Cybervictimization as a function of digital competence at different levels of game addiction after controlling for gender and SES. Low, medium, and high levels of game addiction defined as 1 S.D. below, equal to, and 1 S.D. above the mean level of game addiction, respectively.
engage in a process whereby two or more students attempt to solve a problem by sharing the understanding and effort required to come to a solution. Good CPS skills can, therefore, lead to better problem solving skills, communication skills, leadership skills, as well as enhancing teamwork. Findings from our study showed that good digital competence not only potentially reduced the detrimental effects of media use, but was also associated with better CPS skills, which are important life skills for adolescents.

There is some emerging evidence on the effectiveness of various intervention programs designed to prevent inappropriate media use and gaming addiction. The Wise IT-Use (WIT) programme aims to enhance students’ awareness of internet gaming disorder and risky online behaviours. However, the outcome measures mainly focused on gaming addiction risk rather than promoting digital wellness. Bickham et al. evaluated a more comprehensive program called Screenshots, which is an in-school curriculum that aims to achieve digital wellness and improve young people’s mental health by encouraging positive digital social skills. Despite a relatively small sample size, Bickham et al. demonstrated that the Screenshots program led to improvements in the participants’ knowledge about key concepts of digital citizenship, while reducing negative online behaviour. Our study found an association between prolonged digital device usage and an elevated risk of gaming addiction in children and adolescents, which could be counteracted by digital competence. Future intervention programs should aim to improve the digital competence of young children as well as emphasize the importance of time limits for digital devices. In addition, digital competence could be an important outcome measure in larger randomized controlled trials for intervention programs that promote digital wellness.

Our study can also inform education ministries on education policy to provide clear guidance for schools on internet/gaming addiction and cyberbullying, as such issues are not only a health risk, but also negatively associated with digital competence. Teacher training programs should raise awareness of the risks associated with increased screen time, and help teachers to identify students with or at risk of developing internet/gaming addiction and to recognize cyberbullying. Schools should also develop explicit guidelines on using digital devices during schooltime and implement strategies to address cyberbullying. In addition, digital competence should be made part of the core curriculum and integrated at all levels of schooling. As the use of digital devices for gaming likely occurs at home and cyberbullying may not be easily detected by teachers at school, education policies should also raise parents’ awareness of the detrimental social and health effects of prolonged exposure to digital devices. Strategies linking formal and informal education contexts to support digital competence development should be put into place, and parents, especially those with limited digital competence, should be offered assistance (e.g., workshops offered at universities or events to raise awareness organized by schools).

Our study should be interpreted with the following caveats. This cross-sectional study only reported the associations between digital competence and health outcomes, but did not assess the causal relationships. Longitudinal data are required to further examine these associations over time. Furthermore, there might be recall bias for some variables such as time spent on electronic devices, which were self-reported by the children and adolescents. Finally, we used a new measure of digital competence. Although reliable and without gender DIF, two limitations of the measure are noted and deserve further validation. First, students had the choice of completing the assessment in either Chinese or English. As most students chose the Chinese version, there was an insufficient sample of students completing the English version of the test to examine language DIF. Second, although a comprehensive assessment framework was adopted measuring all five digital competences based on the DigComp, six of 21 sub-competences were not covered in our test (e.g., collaboration). Our team is currently amending and further validating an updated digital assessment instrument.

In conclusion, our study provides empirical evidence that better digital competence is associated with less gaming addiction in children and adolescents. In today’s modern world, with the increasing use of digital devices permeating every aspect of our lives, promoting digital wellness is essential. Parents, educators, and healthcare professionals should equip future generations with better digital competence to maximize the benefits of media use, while reducing the potential adverse effects from the inappropriate use of digital devices.

Declaration of interests
The authors declare no conflict of interest.

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WWYT, FR, NL, NR, JT, KWF & PI had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
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Supplementary materials
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