Exploring efficiencies of informal learning space: a case study
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Abstract
Purpose – Systematic efforts to study students’ use of informal learning spaces are crucial for determining how, when and why students use such spaces. This case study provides an example of an effort to evaluate an informal learning space on the basis of students’ usage of the space and the features within the space.

Design/methodology/approach – Use of heatmap camera technology and a semi-structured interview with a supervisor of an informal learning space supported the mixed-methods evaluation of the space.

Findings – Findings from both the heatmap outputs and semi-structured interview suggested that students’ use of the informal learning space is limited due to the location of the space on campus and circumstances surrounding students’ day-to-day schedules and needs.

Practical implications – Findings from both the heatmap outputs and semi-structured interview suggested that students’ use of the informal learning space is limited due to the location of the space on campus and circumstances surrounding students’ day-to-day schedules and needs. These findings are actively contributing to the authors’ institution’s efforts surrounding planning, funding and design of other informal learning spaces on campus.

Originality/value – While most research on instructors’ and students’ use of space has taken place in formal classrooms, some higher education scholars have explored ways in which college and university students use informal spaces around their campuses (e.g. Harrop and Turpin, 2013; Ramu et al., 2022). Given the extensive time students spend on their campuses outside of formal class meetings (Deepwell and Malik, 2008), higher education institutions must take measures to better understand how their students use informal learning spaces to allocate resources toward the optimization of such spaces. This mixed-methods case study advances the emerging global discussion on how, when and why students use informal learning spaces.

Keywords Mixed methods, Higher education, Case study, Heatmap camera, Informal learning space

Paper type Research paper

Introduction
Relationships between teaching, learning and physical learning space represent a developing field of study across the global higher education landscape (Ellis and Goodyear, 2016; Leijon et al., 2022; Papaioannou et al., 2023). In the past decade, researchers and higher education administrators have become increasingly interested how formal learning spaces (i.e. classrooms used for formal instruction) facilitate teaching and active learning (e.g. Park and Choi, 2014; Holec and Marynowski, 2020). While most research on instructors’ and students’ use of space has taken place in formal classrooms, some higher education scholars have explored ways in which college and university students use informal spaces around their campuses (i.e. spaces not typically reserved for formal instruction) for both personal and collaborative learning activities (e.g. Ramu et al., 2022). Given the extensive time students spend on their campuses outside of formal class meetings (Deepwell and Malik, 2008), it is important that higher education institutions take measures to better understand how their students use informal learning spaces in order to allocate resources toward the

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optimization of such spaces. This mixed-methods case study seeks to advance the emerging global discussion on how, when and why students use informal learning spaces on campus.

Prior research concerning students’ engagement with informal learning spaces in higher education contexts (e.g. Harrop and Turpin, 2013; Wu et al., 2021; Ramu et al., 2022), as well as research interested in students’ use of formal classroom space for informal learning purposes (e.g. Peng et al., 2022), informed features of this case study. While past research has outlined foundations for studying informal learning and use of informal space, we believe there is a scholarly and practical need to establish efficient, replicable approaches for exploring in detail when throughout their daily schedules students use informal spaces, how often they use such spaces and which features of informal spaces specifically they tend to use the most. This case study builds on foundations from prior research to explore these questions and, moreover, to establish efficient approaches for higher education institutions to evaluate the extent to which informal learning spaces on their campuses are meeting their students’ needs.

Heatmap camera technology – in addition to interview methods – supported our exploration into students’ use of an informal learning space in this case study. In a recent study piloting classroom technologies for studying students’ and instructors’ use of classroom space, we found that heatmap cameras offer promise for surfacing trends in space usage during formal instruction (Harris and Birdwell, 2023). Insights from that pilot study – including findings of what heatmap technology can show and how such data can be analyzed – motivated our use of heatmap camera technology to study students’ use of informal space and informed the design of this case study.

Our use of heatmap camera technology also extends existing research using methods for automated data collection in formal classroom spaces (e.g. Spikol et al., 2018; Martinez-Maldonado et al., 2022; Harris and Birdwell, 2023) to informal learning spaces. This is a departure from scholarship that has traditionally relied on manual approaches to data collection to study use of learning space (e.g. Aquillon et al., 2020; Zhu and Basdogan, 2021). We contend that use of heatmap camera technology to collect spatial use data automatically offers an efficient alternative to manual approaches, especially those reliant on qualitative coding of data and time-intensive analyses of audio and video outputs (e.g. Lim et al., 2012; Gurzynski-Weiss et al., 2015). Efficient approaches for studying use of learning spaces are necessary for advancing research on learning spaces in higher education, as well as informing efforts to plan and develop informal learning spaces at the institutional level.

The primary goal of this case study was to better understand the nature and frequency of students’ use of an informal “Student Technology Center” (STC) on our campus. Specifically, we were interested in how students use the space (including which features of the space they use most), why they use it and when they use it throughout the day. Findings from this study will inform decisions among administrative units at our institution regarding how to improve the STC to incentivize more regular student use, as well as where and how to develop informal learning spaces on campus in the future. In summary, our central research questions are as follows:

RQ1. Which features of the STC do students use most frequently? Which features do they use least frequently?

RQ2. What do students do in the STC? What might be their goals for using the space?

RQ3. What times of day do students use the STC most heavily? Why might the STC see heavier use during some time periods throughout a given day than others?

Case study background
The STC is in the Information Technology building at a public research university in the midwestern United States (hereafter referred to as “the University”). The STC is a designated
study lab that opened after renovations in 2020. The room is available for students to use without making a reservation throughout the day, Monday through Friday, and with limited hours on Saturdays and Sundays. The building that houses the STC also houses the university’s Informatics Department alongside offices for Information Technology personnel. The building is centrally located on campus and less than half a kilometer walk from both the university’s main library and the School of Business building, which houses several large departments. The room has a capacity of 25 people and is equipped with 12 personal computers for students’ use, booth-style tables, stationary and mobile whiteboards, a printer and an array of seating arrangements to offer students comfortable spaces in which to study collaboratively or independently. Seating arrangements include four small tables with single chairs designed for individual (as opposed to collaborative) use, two areas with cushioned sofas and arm chairs designed for informal collaboration and/or socializing, individual chairs with wheels for flexible use surrounding the desktop computers in the room and three tables with cushioned booth-style seating designed for more private collaboration. The STC is one of 26 designated study labs on campus; it is one of only three study labs across campus offering similar seating arrangements, both Mac and Windows desktop computers and access to a printer. One of the two other comparable study labs is located in the building that houses the university’s School of Art, and the other comparable space is situated in the building that houses various classrooms not specific to a particular department, alongside offices for academic support services.

We used a heatmap camera to capture evidence of room usage from 8:00 am to 7:45 pm over the course of nine data collection days during September 2022. Given our use of a camera that captures a view of the entire space, and the nature of the heatmap outputs, we sought and obtained approval from the University’s Institutional Review Board (IRB) to ensure our research design followed all guidelines for ethical research activity. We employed descriptive statistics to uncover trends in students’ use of the STC and its various features. As elaborated in the following text, our findings demonstrate the extent to which students at the University use the STC throughout the day, as well as the extent to which they use specific features of the room. Qualitative findings from a semi-structured interview with a recently graduated former student currently employed by the University to supervise the STC provided a more nuanced perspective into how, when and why students use the space. The following images show the STC from different angles to highlight the different technological features and seating arrangements of the space (see Plates 1–3):
Methods

Design and rationale

We followed a mixed-methods approach for studying the use of the STC. In addition to collecting data automatically via the heatmap camera, we conducted a semi-structured interview with one of the employees (a former student who graduated two years prior to the start of this case study) tasked with supervising day-to-day use of the STC and other informal learning spaces around campus. The employee (whom we refer to here by the pseudonym John) met with the research team for 30 min to take part in the semi-structured interview. To ensure that the interview was as authentic and unbiased as possible, John was not given access to any findings from the heatmap outputs prior to the interview. We invited John to participate in the interview phase of this case study specifically because of his firsthand experience both as a student navigating similar informal learning spaces on campus and as an employee who oversees the use of such spaces. We felt it was important to interview someone who could speak to how the space is used from the perspective of both a student and
a staff member. We applied a thematic analysis (Clarke and Braun, 2014) to this qualitative interview data, through which we identified central themes – detailed in the following section – as they emerged throughout our review of the interview transcript. We pursued this mixed-methods approach because it opened pathways for coming to a holistic and nuanced understanding of students’ use of the STC. This approach allowed us to gather data systematically over specified time frames to uncover generalized trends in use of the STC (via the heatmap camera), while also surfacing a more detailed view of how and why students use the space (via our qualitative interview protocol).

Data collection
We used a heatmap camera to systematically and automatically collect observational data of students’ use of the STC during nine data collection days throughout the early weeks of the academic year. The camera was positioned on the ceiling toward the front of the room. The camera operates automatically for 24 h per day (until it is powered off manually) and produces a heatmap output that shows bright red shading in locations where the presence of students is detected. In some cases, the output also shows blurred, unidentifiable images of students sitting in various locations throughout the room (typically when students are sitting close in proximity to the camera). The camera produced an output at 15-min intervals throughout each day of data collection, beginning at 8:00 am EST and ending at 7:45 pm EST (i.e. outputs were produced for 8:00 am, 8:15 am, 8:45 am and so forth up to 7:45 pm each day).

Data analysis
Prior to data analysis, a staff member from the University’s Learning Technologies Division downloaded the heatmap outputs from a remote location for the predetermined time periods and forwarded the files to the research team via a secure institutional email account. Analysis of the heatmap outputs was divided into two phases: the first phase entailed coding the outputs for the total number of students present in the room at each 15-min increment throughout each day (i.e. we counted each individual point of red heatmap shading and each blurred image of students to determine the total number of students using the room at each increment). The second phase entailed coding the outputs for whether any student was using each of the specific room features or areas at every increment. Use of specific features was coded as a binary finding (i.e. if any student was using a given feature at a given point in time, this was coded as “1” for the specific feature; if no student was using that feature at a given point in time, this was coded as “0”).

From the first phase of data analysis, the total number of students using the room at each specific timestamp across all nine days of data collection was divided by nine to determine the average number of students using the room at every individual timestamp throughout the day. For example, if 17 students in total were occupying the room across each 8:30 am timestamp from all nine days, we calculated the average number of students using the room at 8:30 am to be approximately 1.89 students (17 students using the room at 8:30 am across all days, divided by 9). From the second phase of data analysis, we used the binary codes for whether students were using each individual room feature at every timestamp to calculate the total number of instances in which each feature was in use across all nine days. We then calculated the proportion of use for each feature. For example, the collaboration booths were in use six times across all days; we divided this by 171 (the total number of times any feature was in use at each given timestamp across all days) to find that the use of the collaboration booths represented approximately 5.10% of students’ use of the various features in the room.

We divided our evaluation of usage of the STC based on five points of focus corresponding with specific features of the room. These features were (1) entry tables on the far-left side of the room, (2) the technology center computers placed on tables throughout the center of the
room, (3) the collaboration booths alongside the outer walls, (4) the tables and seating area along the wall to the right of the entryway where students use personal devices and (5) the sofa area on the far-right side of the room. The image (Plate 4) shows the physical locations of each feature throughout the room:

On the heatmap outputs, red shading showed where students were using the room – and which specific features they were using – at each given point in time throughout each day of data collection. In some outputs, blurred images of students were visible in various parts of the room. These blurred images were considered alongside the red heatmap shading when coding the outputs for student usage.

The following is a representative sample of images captured from the heatmap camera in the STC. All captured on the same data collection day, the image on the left taken at 11:30 am shows students using personal devices, occupying the entry tables and the sofa area and using the technology center computers. This output was coded as having a room occupancy of four students (one student at each of the four room features per the red heatmap shading). The middle image captured at 12:30 pm shows evidence of students using personal devices, occupying the entry tables and collaboration booths and using the technology center computers and was also coded as having an occupancy of four students. The image on the right, captured at 6:30 pm, showed no red heatmap shading and was thus coded as having a student occupancy of 0 (see Plate 5).

Results

Our findings showed clear, discernable trends in students’ usage of the STC. After calculating average total use of the room for each point in time, we found a trend in which the room saw modest usage early in the morning (from 8:00 am to 9:30 am). During this period, one or two students typically occupied the room. These numbers gradually increased throughout the
late morning (from 9:30 am to 12:00 pm). During this period, two to four students usually were using the room. This trend of gradual increase in usage continued into the early afternoon period (roughly 12:00 pm to 2:00 pm). The period when the room saw the most student usage was during the mid-afternoon period (2:00 pm to 4 pm), in which four or five students, on average, occupied the room. The time when the room tended to be most occupied was 2:45 pm, in which nearly five students occupied the room on average over the course of the nine-day data collection period (see Figure 1).

After 4 pm, average room usage declined sharply. By 5:30 pm, only two students were typically in the room at a time during the data collection days. By 6:30 pm, average room usage had declined to between 0 and 1 student occupying the room at a time for the rest of the evening.

Interestingly, average room usage declined sharply during the late afternoon and evening periods. This rate of decline appeared to be faster than the rate of increase in average room usage throughout the morning and early afternoon periods. It is possible that this aligns with students’ class schedules throughout the day. For example, if most classes on campus are held mid-morning through mid-afternoon (i.e. between 9:30 am and 4 pm), students might be inclined to use the room as they arrive on campus leading up to the start of their classes, as well as

![Plate 5. Sample heatmap outputs of the STC at various times of day](image)

![Figure 1. Average number of students in the STC at different times throughout each day](image)
between classes during the middle of the day. And if classes end for the day in the mid-to-late afternoon, students might be less inclined to stay on campus and use the room (which would result in rapidly declining average usage throughout the afternoon and into the evening).

Our findings also yielded insight into the specific features of the room that students use most frequently. Out of all five of the room features of interest, the personal device tables were used most often (40.20% of total usage across all features). Use of entry tables and use of computers in the technology center were also common (representing 24.80 and 22.20% of usage, respectively). Use of the sofa area (7.70%) and collaboration booths (5.10%) was far less common. The following pie chart represents the proportion of total usage for each specific feature of the room.

The themes identified through our analysis of the interview with John, the former student who now supervises the STC, offered a detailed, nuanced view into the nature of students’ use of the space. The central themes that emerged throughout the interview were (a) students’ purposes for using the STC, (b) how students’ schedules influence their use of the STC and (c) why the STC may be an underutilized space. Table 1 outlines these central themes and offers example excerpts from the interview that represented each theme. This rich qualitative data complemented the observational data captured by the heatmap camera. In some ways, the interview with John provided clarity on what the heatmap outputs suggested about students’ use of the space. From the heatmap outputs (as shown in the pie graph in Figure 2), it appeared as though the personal device tables were by far the most frequently used feature of the space. Even without having seen any of the heatmap outputs, John volunteered that access to power outlets seemed to be a primary reason students were drawn to using the STC. This aligns strongly with the strong preference for use of the personal device tables demonstrated in the heatmap outputs and maps onto our first main theme: students’ purposes for using the STC. In other words, it is quite possible that students who used the personal device tables in the STC did so because of their proximity to power outlets to charge their personal electronic devices such as cell phones, tablets and laptop computers. Based on John’s insights and the heatmap outputs, it is possible that access to power outlets specifically is one affordance students seek in informal learning spaces.

The interview with John also offered insights into why and when students might use the space. John suggested that much of the students’ use was likely due to convenience – some students were taking courses in classrooms that were nearby the STC, and the STC offered them a venue in which to gather, study and/or relax between their course meeting times. This gave rise to the second theme uncovered in our analysis: how students’ schedules influenced their use of the STC. John’s insights related to this theme aligned with trends demonstrated through the heatmap outputs, suggesting that the STC saw its heaviest use during the middle of the day when classes were typically in session, as opposed to earlier in the morning before class or in the evenings after classes had concluded.

Furthermore, John stated that given the STC’s location on campus (in a building that serves certain departments, and in which classes within those departments are taught), use of the space may have been limited to students who enrolled in classes in those departments. John explained that since the STC is not located in a building heavily visited by most students, relatively few students have an explicit reason to enter that building. Therefore, use of the STC may be more common among students studying within the departments the STC’s building serves, which naturally limits use of the STC to a smaller group of students. This part of the interview discussion maps onto our third theme: why the STC may be an underutilized space.

Discussion
Altogether, our findings suggest that students’ usage of the STC over the course of the data collection period was limited. As the bar graph shows, the room saw the most usage in the
mid-afternoon. Even during that time frame, not many students tended to occupy the space—typically no more than five students at a time. Later in the afternoons and into the evenings, the room saw consistently little use; during two of the data collection days, no students used the room at all after 6:15 pm. We interpret these findings as suggesting that the STC is an underutilized space, and the interview with John corroborated this. Moreover, the evidence suggesting that the entry tables are the most frequently utilized feature of the room supports this notion—it is possible that many students using the entry tables do so in passing between classes or on their way in and out of the building, and thus may not represent intentional or planned use of the space. From both the heatmap outputs and interview findings, it is possible to infer that the underutilization of the space is due in part to both lack of convenience

<table>
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<tr>
<th>Theme</th>
<th>Relevant excerpts</th>
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<tr>
<td>(a) Students' purposes for using the STC</td>
<td>“... a lot of times those booths are getting used simply because they're the closest thing to power. ... Comfortable seating next to a power location, so even if they're not getting used collaboratively, they're getting used for the resources that just being in that booth supplies.”</td>
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<td></td>
<td>“I have a group of marketing students that are doing class projects in [a similar informal learning space on campus]. And one of the things I asked them is sort of like, OK, what about this space intimidates you or what are you looking for when you go into spaces like this? And I think unanimously, the decisions were power and available seating.”</td>
</tr>
<tr>
<td>(b) How students' schedules influence their use of the STC</td>
<td>“I would say periods of time from 10am to around 4pm is usually the most intense time periods... a lot of them are just kind of killing time before their class starts and needed a place to sit. But I would say that after 5pm, spaces like that dip off drastically in their attendance.”</td>
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<td>“I know a lot of those major programs have late night courses that are going to be dragging them away from that area. So I noticed that if I have to go over there to service any of the machines... or be in that space, I usually only notice that students are in there up until about 4:00 o'clock...”</td>
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<tr>
<td>(c) Why the STC may be an underutilized space</td>
<td>“... I think it’s... Location on campus and being in the IT building sort of has a niche group of students that are usually visiting that space. So if we’re being honest, my opinion is that it is currently underutilized... However, [administrators have] sort of been monitoring this and talking with some other students and so to sort of go with that student need.”</td>
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<td>“... just from being a student at [the University], a lot of the courses and stuff that get hosted in there are the school of Informatics, programming, engineering, mathematics, and game design, game development. So all of these people... are already sort of in the world of technology one way or another. So these are definitely the people that I see utilizing our technology centers.”</td>
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<td>“I think that it’s almost in competition with the other spaces around campus and I think just it’s location is sort of the detriment to why that room seems like it’s being underutilized because there’s nothing really... There’s no glowing treasure chest effect really, for that room of—we, let’s go here, let’s do this, let’s be in this room because when at the end of the day, when you’re looking at the features and functionality of that space, it’s honestly no different than a lot of our other technology centers around.”</td>
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**Source(s):** Author’s own work

### Table 1.
Representative excerpts for each theme that emerged from the semi-structured interview
(i.e. students’ daily schedules typically not taking them near the STC) and misalignment with students’ everyday needs (i.e. not necessarily needing to use desktop computers or collaborative working spaces but simply needing access to power outlets).

Our findings from both sources of data offer rather straightforward answers to each of our main research questions. We found that students tended to use the personal device tables far more frequently than any other feature – presumably because of their proximity to power outlets – and that they used the collaboration booths the least often. Relatedly, we found that students typically used the STC for personal study between classes, often using the power outlets in the room to charge their personal devices. This is perhaps the most striking finding of this case study given the space design’s focus on seating arrangements configured for collaborative work (and given the institutional investment required for this new, comfortable furniture designed specifically to promote collaboration). Finally, we found that students used the STC most frequently during the middle of the day, presumably around the same times their classes were scheduled to meet. The heatmap outputs suggested that students typically did not access the room in large numbers toward the end of the day (i.e. after classes had concluded), and insights from the interview with John suggested that the STC does not make for an accessible evening study space given its obscure location.

Our findings also support insights from past scholarship (e.g. Anggiani and Heryanto, 2018), suggesting that easy access to electrical outlets is crucial for encouraging students’ use of informal learning spaces. The heatmap outputs showing heavy use of the personal device tables (each stationed next to an electrical outlet) relative to other areas of the STC, alongside John’s strong views relevant to this articulated in the interview, suggest that students gravitate toward spaces that allow them to charge their devices while studying informally. To build useful and effective informal learning spaces, universities should ensure that such
spaces are sufficiently outfitted with electrical outlets so students can charge their personal devices such as cell phones, laptops and tablets.

Given the immense resources institutions devote toward designing, building and furnishing informal learning spaces like the STC (Berman, 2020), it is necessary to evaluate the effectiveness of these spaces regularly. Heatmap cameras and other technologies that support automated data collection could help institutions evaluate students' use of their informal spaces at scale. Regular evaluations that identify generalized and specific trends in how, when and why students use informal spaces may offer valuable information with which to guide design plans for future spaces and, ultimately, to ensure that resources are being used effectively and efficiently. Our findings advance foundations for leveraging heatmap technology as an approach for evaluating the extent to which institutional investments in informal spaces are meeting students' needs.

**Limitations and directions for future research**

It is worth considering the time of year in which we collected room usage data with the heatmap camera. Given that we collected the heatmap data quite early in the school year, it is possible that many students had not had opportunities to find the space or become acquainted with what it offers. This is a possible limitation and likely constrains the extent to which we can generalize the findings from the heatmap camera to other times throughout the school year. It is feasible that collecting data toward the middle or end of the school year could have shown heavier use of the STC if students had had a longer period of time to familiarize themselves with the space and its affordances for informal learning. Future explorations of use of the STC and other informal learning spaces will prioritize collecting data over a longer time period throughout the year, including both the beginning and concluding weeks of the academic term.

Despite limitations related to the data collection period, this case study offers several critical insights about students' use of informal learning spaces and how universities could design spaces that draw students to them consistently. The nuanced perspective John provided during the interview portion of the study offered particularly useful insights into how a space like the STC could be more attractive for students on a regular basis, rather than merely during certain transitory times of the day. The impact of the room's location on campus was a particularly salient point. John emphasized that since the STC is located in a building that serves particular academic departments, use of the space is mostly limited to the students taking courses in those departments. Had the STC been situated within or adjacent to the campus library or other buildings frequented by larger groups of students, John postulated, students would use the space in larger numbers and on a more consistent basis. When planning developments for informal learning spaces, universities should consider situating these spaces in areas that are highly visible and accessible to as many students as possible. Spaces situated within or near campus libraries, dining or residential areas and in buildings that house departments with large student enrollments are positioned to maximize student engagement. This case study's findings suggest that no matter how well-developed and technologically enhanced an informal learning space is, its use may be limited by its location. Future research should examine trends in usage of similar spaces near highly visible areas. On this particular campus, the study lab with comparable affordances situated near student support services may offer a useful comparison given how frequently students visit the building to access various services relative to the building housing the STC analyzed in this study.

**Conclusion**

Beyond evaluating the extent to which students use the STC and its specific features, this case study advances the use of heatmap camera technology as one approach for collecting data
related to use of informal learning spaces. Such automated approaches to data collection promise to bolster institutional efforts to better understand how their students use informal spaces, which is crucial for maximizing space for student learning and engagement and ensuring institutional resources are used as effectively as possible. Heatmap camera technology also holds promise for supporting data-driven decision-making among stakeholder groups comprised of different university personnel. We believe that heatmap data have the potential to surface trends in use of learning space in ways that are accessible to faculty of various disciplines, administrators and technology personnel with varying levels of research and evaluation experience. Given the need to survive in the higher education marketplace, institutions must draw on insights like those uncovered in this case study to continue adapting to meet their students’ wants and needs for informal spaces on their campuses.

References


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