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Information problem solving during a digital authentic task: A thematic analysis of students' strategies

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ABSTRACT

In the digital age, information problem solving (IPS) competence is essential for professionals to use online information effectively. Despite its importance, starting professionals often struggle with processing and presenting information, which are critical phases during authentic IPS tasks. Therefore, higher education institutions are tasked with preparing students to navigate these complex phases of IPS after graduation. However, most previous studies have focused on the "search" and "select" phases of simple, short-duration IPS tasks, which do not reflect the complex information challenges faced in professional settings. To address this gap, this study aimed to identify and categorize the strategies higher education students currently use to process and present information for a semester-long authentic professional task. A thematic analysis of cued retrospective reporting sessions was conducted with 24 senior students while they created a website for professional practice. Students demonstrated 49 IPS strategies, which were categorized into twelve IPS activities across three generic activity phases: "process," "synthesize," and "create." Within these phases, three patterns of co-occurring strategies were observed: reproductive, arranging, and elaborative. Based on these findings, existing IPS process models were empirically refined. The observed variation in strategies highlights the importance of building on students' strengths when teaching IPS. Teaching them to adapt the strategies to various authentic task contexts could help enhance students' IPS competence and strategic flexibility in real-world settings. Future research should explore the applicability of the updated IPS model across different authentic task contexts to refine instructional approaches further.

1. Introduction

Higher education institutions are expected to equip upcoming professionals with the necessary digital competence to address the challenges of modern society. This includes proficiency in information problem solving (IPS), which is crucial for using online information to solve problems and construct new knowledge (Brand-Gruwel et al., 2009; Eisenberg & Berkowitz, 1990). Developing IPS competence is vital for professional success (Pandita & Singh, 2012, pp. 331–337; Sharun, 2019), equipping professionals to access, manage, create, and communicate information effectively (Head, 2012; Katz et al., 2010). Despite its importance, many graduates lack the proficiency in IPS needed in the workplace (e.g., Herring, 2011; Jeffryes & Lafferty, 2012; OECD, 2015). This deficiency impedes their ability to effectively use online information in professional tasks and risks basing professional decisions on inaccurate, biased, or outdated information. Consequently, higher education institutions must identify and implement effective teaching strategies that enhance IPS competence among future professionals (ACRL, 2016).

The current scientific knowledge base on IPS teaching for professional purposes provides limited guidance for developing such instructional support due to several gaps in the literature. First, research primarily examines simple, short-duration IPS tasks that may not reflect the complex information challenges graduates face in professional

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settings (Garcia & Badia, 2017; Walton & Hepworth, 2011). Second, existing studies mainly focus on the "search" and "select" phases of IPS, while the more complex "process" and "organize and present" phases are largely underexplored (Authors et al., 2024; in prep.; Garcia et al., 2021). Third, there is a predominant focus on academic IPS tasks such as writing literature reviews, with less exploration of professionally oriented IPS tasks like creating infographics or a website for professional practice (Authors et al., 2024; in prep.; Rader, 2002). This indicates the need for further research to help instructional designers prepare students for all phases of the complex IPS tasks they will face in their professional careers.

This study addresses the gap in the literature related to the underexplored "process" and "organize and present" IPS phases in authentic task contexts. At the theoretical level, providing detailed insights into how students operationalize these IPS phases helps to tailor IPS models to authentic tasks. At the practical level, understanding students' strategies allows educators to build on their strengths and develop scaffolding techniques to help them adopt more sophisticated approaches. Therefore, this research aims to identify and categorize higher education students' strategies for processing and presenting information during an authentic professional IPS task.

2. Theory

2.1. Information problem solving competence

To explore how students approach authentic IPS tasks, it is necessary to analyze the foundational theories that form the conceptual basis of IPS competence. The literature explores IPS competence through the lens of performance—evaluating an individual's ability to tackle information problems—and the IPS process, which focuses on the activities involved in IPS tasks.

From the perspective of performance, IPS competence is seen as a set of integrated abilities that enable individuals to solve information problems in a specific professional domain, job, role, organizational context, and task situation (Monereo & Badia, 2012; Mulder, 2014). These integrated abilities encompass "the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning" (ACRL, 2016, p. 8). Rather than viewing the integrated abilities of IPS as mere skills, we consider them complex competencies, or "coherent clusters of knowledge, skills, and attitudes which can be utilized in real performance contexts" (Mulder, 2014, p. 111). For instance, domain-specific knowledge, evaluation skills, and critical attitude interact while assessing source credibility (Kammerer et al., 2013; Lucassen & Schraagen, 2013; Salmerón et al., 2013). This complex interplay between knowledge, skills, and attitudes determines students' IPS performance, which can be understood as the measurable outcome of their IPS competence in practical IPS scenarios.

From the perspective of the IPS process, various theoretical models have been proposed to decompose the cognitive activities that make up the IPS process. While many of these models are conceptual, the IPS-I model by Brand-Gruwel et al. (2005, 2009) is based on empirical research conducted in online educational settings. Despite being developed initially based on academically oriented IPS tasks, the model has been successfully applied to professionally oriented tasks (e.g., Brand-Gruwel & Wopereis, 2006), demonstrating its suitability for our context. Although its authors describe five "constituent skills" for solving information problems using the internet, we align with Lazonder and Rouet (2008) in viewing them as activity phases. The five activity phases, as defined in the IPS-I model, are: (a) define the problem, (b) search, (c) select, (d) process, and (e) organize and present information, each consisting of various activities (see Fig. 1). These activity phases are highly interrelated, whereby regulation of the process is integral to each of these (Brand-Gruwel et al., 2009; Winne, 2019). Researchers see these activity phases as a consecution of increasingly complex activity phases that build upon one another (Brand-Gruwel et al., 2009; Eisenberg & Berkowitz, 1990).

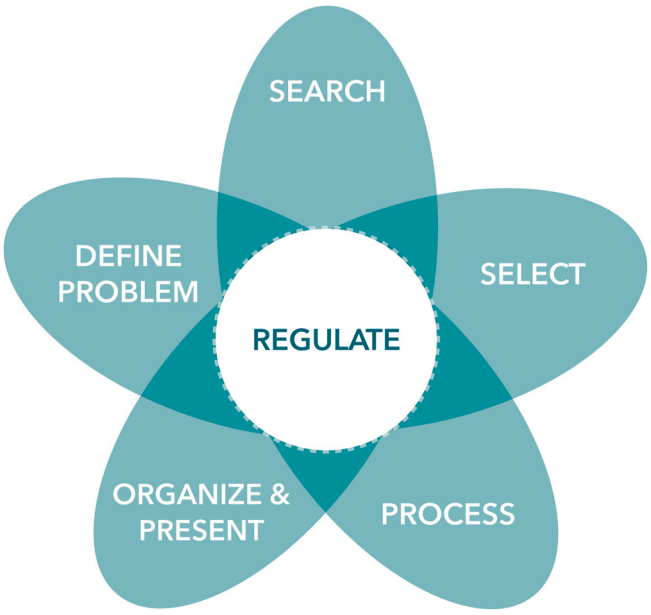

Fig. 1. The five interrelated activity phases of the iterative information problem solving process (based on Brand-Gruwel et al., 2009).

2.2. "Process" and "organize and present" information

As the activity phases in the IPS process become more complex, the difference between experts and novices becomes increasingly apparent. Experts invest more time to "process" and "organize and present" information, employing sophisticated strategies (Brand-Gruwel et al., 2005). In contrast, novices often struggle with these complex phases, resorting to superficial strategies such as direct copying and pasting (Azevedo et al., 2004; Brand-Gruwel et al., 2005; Probert, 2009). They struggle to synthesize the information they find and integrate it into their own work (Mateos & Solé, 2009; Rosenblatt, 2010). Therefore, this study focuses on the complex "process" and "organize and present" phases of IPS.

The "process" phase involves analyzing information to deepen understanding and connect it to prior knowledge (Argelagós et al., 2022; Wopereis et al., 2008). The three key activities in this phase are in-depth reading, critically evaluating, and elaborating on sources and information (Brand-Gruwel et al., 2009). The "organize and present" phase focuses on integrating all gathered information into a coherent product. This phase includes five key activities: formulating the problem, structuring information, outlining, realizing, and elaborating on the content (Brand-Gruwel et al., 2009). Together, the "process" and "organize and present" phases result in the synthesis of information from various sources into a new knowledge product.

2.3. Strategic learning perspective

Successful IPS in real-world scenarios rarely follows a linear application of these activities (Badia & Becerril, 2015). Instead, IPS is an iterative process where individuals frequently cycle back and forth between different activity phases (Brand-Gruwel et al., 2009; Walraven et al., 2009). From a strategic learning perspective, IPS activities and their timing can vary depending on the task's specific characteristics (Becerril Balín and Badia Garganté, 2013; Monereo & Badia, 2012). For instance, recent adaptations to the IPS-I model for tasks involving conflicting information have incorporated activities such as "compare and contrast information" and "synthesize information" into the "process"

and "organize and present" phases, respectively (Frerejean et al., 2016; Pifarré & Argelagós, 2020). Such adaptations demonstrate the importance of using tailored IPS activities and strategies for effective performance in specific IPS tasks (Rouet et al., 2009; Wiley et al., 2009). Adopting this perspective, we apply the IPS-I model as a contextually adaptable framework rather than a prescribed process.

3. This study

This study aimed to identify and categorize higher education students' strategies during the "process" and "organize and present" phases of an authentic IPS task. By understanding these strategies, educators can build on existing strengths and develop scaffolding techniques to promote more sophisticated approaches. The ultimate aim was to guide the development of educational interventions aimed at improving students' ability to process and present information effectively in authentic IPS tasks. These aims were guided by the overarching research question: What strategies do higher education students employ when processing and presenting information during an authentic IPS task?

4. Methods

A thematic analysis of cued retrospective reporting sessions explored how higher education students engage in a professional IPS task, focusing on the "process" and "organize and present" phases. This qualitative approach allowed for an in-depth examination of the participants' IPS strategies within an authentic setting (Rubin & Rubin, 2012). The study was conducted at a teacher training institute at a large University of Applied Sciences in the Netherlands, known for its professionally oriented curriculum. The study followed strict ethical standards in accordance with national guidelines.

4.1. Participants

Twenty-four senior undergraduate students volunteered to participate in this study. The participants (fourteen female, ten male; mean age 28.83, SD = 7.32) were typically fourth-year students enrolled in a full-time program. Senior students were selected to offer insights into the preparedness of soon-to-be professionals for authentic IPS tasks in professional settings. Participants were primarily pre-service teachers in secondary language education ($n = 12$), secondary STEM education ($n = 6$), and primary education ($n = 4$). The self-assessed computer skills of the participants were primarily average, with many having moderate to substantial experience in designing digital educational materials. Table A.1 presents the demographic characteristics of the participants in more detail.

Participants were recruited through convenience sampling (Etikan et al., 2016) from a cohort of 30 students enrolled in the 2.5 ECTS "Digital Information Problem Solving" course (henceforth: IPS course). Convenience sampling was chosen for its practicality and to ensure the participants were senior students undertaking an authentic IPS task. In the first class, the researcher provided details about the study, and all students received an information letter and consent form via email. The information letter outlined the research aims, procedures, data usage, contact information for the researcher, and participants' rights, including detailed withdrawal procedures. Students indicated their willingness to participate by signing the consent form.

4.2. Educational context and task

The teacher training institute organized the IPS course in Fall 2023 as part of the 30 ECTS "Digital Literacy and Educational Games" minor. The IPS course, linked to the parallel "Educational Websites" course, aimed to support students' IPS process while designing digital educational materials. Table A.2 shows an overview of the course contents and timeline. It included six 60-min face-to-face sessions, each focusing on one IPS activity phase. These were followed by out-of-class assignments to apply the learned contents to the semester-long educational website project.

In the context of this study, students were tasked with creating specific components for their educational website project, such as writing webpage content or designing an infographic. This task was chosen for its authenticity, as designing digital educational materials mirrors a task that educators encounter in their professional practice. The task's complexity and open-ended nature made it suitable for eliciting various information processing and presentation strategies in authentic IPS tasks.

4.3. Procedure

After signing the informed consent form, participants were invited to a 60-min online session. Participants were instructed to prepare in advance by gathering all necessary materials, such as notes or sources. The sessions were scheduled from weeks three to four of the IPS course to exclude immediate instructional influence on the "process" and "organize and present" phases. Due to scheduling conflicts or illness, five sessions were scheduled between weeks five and seven. The sessions took place through the *Microsoft Teams* video call function, allowing participation from personal digital devices at preferred locations, thus enhancing ecological validity.

Table 1 shows the three phases of the research sessions: pre-task interview, task execution, and retrospective interview. At the beginning of the session, participants were briefed on the goals and procedure of the session. They were also familiarized with the task and could ask questions about it. After verbally confirming their consent, the pre-task interview was conducted. Following this, participants were asked to work for 25 min on the task without direct researcher interaction, simulating their typical work environments. They were allowed to play background music or engage in self-talk if these were part of their usual working habits. The researcher observed and recorded the participants' screen actions, ending the recording at a natural stopping point, typically upon completion of an activity. Immediately following the task, the retrospective interview took place, concluding with a final reflection.

4.4. Data collection

Data were collected from three primary sources: recordings of pre-task interviews, participants' screen recordings, and recordings of cued retrospective interviews. All recordings were made using *OBS studio* (version 30.0.2) software.

4.4.1. Pre-task interview

Pre-task interviews were guided by a structured interview schedule (Appendix A). This interview schedule consisted of (i) an introduction to the goal, procedure, and consent for recording the screencast and (ii) some preliminary questions on demographic characteristics, prior competence, and the goal of what the student will work on during the screencast.

4.4.2. Task execution

Screen recordings were used to capture real-time, objective data on participant behavior during the execution of the IPS task. This method provided a visual and temporal log of IPS activities, facilitating unobtrusive observation independent of participants' subjective interpretations. Screen recordings averaged 23 min and 45 s (SD = 2 min and 5 s). Alongside these recordings, a structured note-taking schema was used to document critical moments and initial reflections during task execution (see Appendix B). This schema used a tabular format to systematically record observations with timestamps, linking specific strategies to the IPS activity phases.

Table 1
Set-up of the cued retrospective interview sessions.

Part	pre-task interview	task execution	retrospective interview
Duration (min.)	5	25	30

4.4.3. Retrospective interview

To collect information about participants' cognitive processing during task execution, the cued retrospective reporting method was used (Van Gog et al., 2005). Participants were asked to retrospectively verbalize their thoughts based on a cue of their performance. Immediately following the task, participants' screen recordings were played back as a cue for retrospective reporting interviews. This immediate transition was intentionally designed following Gibson's (1997) methodology to collect reliable retrospective data. During the playback, the recording was intermittently paused to ask probing questions, enabling a more profound exploration of specific decisions and strategies.

Retrospective reporting was chosen for its ability to provide a deeper analysis of cognitive processes in complex tasks like website creation, as suggested by prior IPS research (e.g., Walraven et al., 2009, 2010). Concurrent verbalization in such cognitively demanding tasks could overly burden participants, thereby interfering with their natural performance (Charters, 2003; Ericsson & Simon, 1980; Russo et al., 1989). Adding a cue during retrospective reporting yields richer data on participants' actions, strategies, and metacognitive processes (Van Gog et al., 2005) and leads to more reliable results because of less forgetting or fabricating of thoughts (Van Someren et al., 1994).

The cued retrospective interviews were guided by a semi-structured interview guideline (see Appendix C). Instructions and prompts were worded in line with the standards of Ericsson and Simon (1980), using neutral, non-leading language and open-ended questions. This guideline was pilot-tested with two participants from the same cohort to refine questions, timing, and cueing techniques. Consequently, the participants included in the main study were numbered from 3 to 26 to reflect the subsequent 24 participants who were part of the analysis. The final interview guideline included four main types of questions: (a) reflective questions about participants' overall approach; (b) general prompts to facilitate continuous verbalization; (c) action-specific inquiries that were directly informed by the observation notes, focusing on clarifying the rationale behind observed strategies; and (d) assessments of the strategies' representativeness. The session concluded with a final reflective question that allowed participants to summarize their overall approach and reflect on the task.

4.4.4. Data management

A data management plan was developed with a senior data specialist to ensure that all personal information and research data were handled confidentially. To ensure participant privacy, all personal data was anonymized, and all other identifiable information (e.g., school names) was pseudonymized. All raw and processed data were securely stored, with restricted access limited to the research team only. Data for which participants consented to be published on a research repository were made available on OSF (Center for Open Science, 2024): https://osf.io/e9p3k/?view_only=976a49804c9c4bd99ef46967d67f7a91).

4.5. Data analysis

4.5.1. Transcription

The video recordings of the cued retrospective interviews were transcribed using *AmberScript* (version 2023). The machine-generated transcripts were carefully reviewed and corrected against the original recordings to ensure accuracy. The resulting transcripts were exported as an *MS Word* file with time stamps for each quote to enable precise data traceability.

4.5.2. Thematic analysis

The data collected were analyzed using thematic analysis, which aims to identify patterns within and across rich datasets (Braun & Clarke, 2012). Thematic analysis was chosen for its flexibility in accommodating various data collection methods and theoretical frameworks (Terry et al., 2017). The analysis followed the well-established six-phase approach of Braun and Clarke (2006), with codes representing strategies, categories representing activities, and themes representing activity phases.

First, two researchers familiarized themselves with the data by repeatedly reviewing observation notes, screen recordings, and interview transcripts, noting common themes and ideas for codes. Second, initial strategy codes were generated using open coding based on the reported "process" and "organize and present" strategies. Third, strategies were categorized into IPS activities and thematized into activity phases, using the activities and phases of the IPS-I model as initial categories and themes. Fourth, the strategies, activities, and phases were reviewed to ensure they reflected the data accurately, with adjustments and expansions made as necessary. Fifth, the final activities and activity phases were named, defined, and revised with the author team, resulting in a final thematic coding scheme (see Appendix D). Sixth, a comprehensive report was produced, documenting the findings and their implications.

The thematic analysis was mainly based on inductive (data-driven) coding, incorporating the deductive (theory-driven) element of using the IPS-I model for the initial IPS activities and activity phases. This combination of inductive and deductive coding is commonly used in thematic analysis studies (e.g., Proudfoot, 2023; Szolin et al., 2023).

All coding was conducted using *Atlas.ti* software (version 23.3.4). To reduce the chance of bias, the main author and a second researcher independently applied the initial codes to 10% of the data ($n = 3$), discussed discrepancies, and reached a consensus on an updated set of codes. Using these updated codes, the same two researchers then independently coded 20% ($n = 6$) of the data, achieving an interrater reliability of Krippendorff's $\alpha = .82$. As the interrater reliability was sufficiently high (i.e., higher than .70; Van Someren et al., 1994), the second researcher proceeded to code the remaining data. Any doubts were documented in memos and discussed with the main author to enhance validity. Lastly, the main author revised the coded data once more using the final thematic coding scheme.

4.5.3. Co-occurring strategies

To identify patterns of co-occurring strategies, both researchers independently reviewed the screen recordings and the coded protocols. They then discussed their overall impressions of co-occurring strategies and possible patterns among participants. To ensure reliability, the researchers independently analyzed 20% ($n = 5$) of the participants in depth. This analysis consisted of three parts: (i) quantifying the type and frequency of strategies used per participant based on *Atlas.ti*'s code-document analysis; (ii) summarizing the main approach used during the "process" and "organize and present" activity phases; and (iii) selecting a characterizing quote for each participant. After establishing a consistent approach, the second researcher analyzed the remaining 80% ($n = 19$) of participants using this method. To maintain reliability, the first researcher regularly reviewed a sample of these analyses. The final

analyses were then discussed with the author team to identify patterns in strategy use among participants, selecting three participants that best reflected these patterns. A detailed analysis of these exemplar participants are included in Appendix E.

5. Results

The analysis aimed to identify and categorize higher education students' strategies when working on a complex professional IPS task, specifically focusing on the "process" and "organize and present" activity phases. Through thematic analysis of cued retrospective reports, 49 strategies were identified and categorized using the phases of the IPS-I model as initial categories (Brand-Gruwel et al., 2009). This resulted in a set of twelve activities distributed over three activity phases: "process information," "synthesize information," and "create product". Table 2 presents the frequency distribution of the observed strategies across these three activity phases, demonstrating that all phases were substantially represented in the population. This indicates that participants engaged in a wide range of IPS strategies and activities during the authentic task of creating a website for professional practice.

Observations led to adjustments and additions to the "process" and "organize and present" phases of the original IPS-I model. The variety of strategies and activities observed within the "organize and present" phase highlighted the need for clearer conceptual separation. Therefore, this phase was split into two phases: "synthesize" and "create." This separation addressed the distinction observed in our data between synthesizing multiple pieces of relevant information and the actual creation of the final product. Furthermore, introducing the "synthesize" phase allowed for the conceptual separation between processing individual pieces of information and synthesizing them into a cohesive whole.

5.1. Process information

The "process information" activity phase involves engaging with individual pieces of information to deepen understanding and transform them to suit the final product. Four activities were identified within this phase: one existing, one renamed, and two new activities. The addition of "extract relevant information" and "transform information" as separate activities stemmed from their frequent occurrence and the absence of a suitable existing activity in the original model. Fig. 2 illustrates the observed strategies during this phase.

Analyze in depth. This activity involved participants engaging deeply with the source content to gain a comprehensive understanding. This activity was renamed from the original "read text in depth" to better reflect the diverse range of sources, including multimedia, that participants processed. Commonly observed strategies include reading a text in silence or aloud, one or multiple times, using the cursor as a reading aid, and marking text within a source. For example, Participant (hereafter referred to as "P") 6 mentioned that reading the text aloud helped to understand the text better: "*That helps me because when I hear it out loud, it seems like yes, um, yes, that that, I don't know. But then I feel, then I feel that text more.*"

Critically evaluate. During this activity, participants critically analyzed the source and information for bias, validity, and applicability to the task. Participants frequently used verbalization strategies such as commenting aloud or mentally or reading aloud to assess the quality and relevance of the sources. For example, P6 discarded irrelevant content by commenting out loud while reading a source: "*Oh, that is not relevant to my website*" (P6). Within these comments, they often considered their target audience to evaluate relevance: "*There is just a lot of text that is not really of much use to my students*" (P7). To assess the credibility of the source, participants also looked at whether the information corresponded to their prior knowledge: "*I check [the information] with my own knowledge: does it kind of correspond?*" (P19).

Extract. In this activity, participants sifted through sources to isolate the most pertinent information or concepts. The two most common strategies for this activity were directly transferring information and compiling information. Some participants directly copied and pasted information from sources to their own websites: "*I just literally used it*" (P14). The copied information included both text and visuals from either external sources or previously created work: "*So I thought […] I can easily make a screenshot from my own Powerpoint and put that one in*" (P18). Other participants first compiled all relevant information into a Word document before further processing it, as described by P12: "*[I make] a list of statements or pieces of information that appear in sources, with behind them what source and where that is.*" During this extraction, several participants split their computer screens or used multiple tabs to switch between the information source and their own product.

Transform. During this activity, participants adapted and altered the information to fit the particular demands of their final product. To this end, they used strategies such as paraphrasing, translating, and summarizing information. For instance, P21 mentioned: "*I just write [it] in a slightly different way that is a little easier to understand […] for my students*." Changes also included visual modifications of the text in order to improve it for their target group, as done by P16: "*[I] make it red so that it's clear: Okay, so step one is the stem [of the verb.]*" Style changes were also noted where participants transformed original content to adapt it to website-friendly content: "*I don't like that myself with those [academic] sources in the running texts on a website*" (P6). Notably, generative AI tools such as ChatGPT were also used to translate, summarize, and refine content further: "*So I had a summary […], and then I let ChatGPT rewrite it into nicer pieces of text that are not too long*" (P14).

Table 2
Frequency distribution of observed strategies across IPS activity phases and activities.

Activity phase	Frequency strategies
Process Information	145
(a) analyze in depth[a]	17
(b) critically evaluate	31
(c) extract[b]	49
(d) transform[b]	48
Synthesize Information	101
(a) compare and contrast[b]	11
(b) organize	36
(c) integrate[a]	6
(d) elaborate	48
Create Product	204
(a) conceptualize[b]	45
(b) outline	52
(c) design[a]	60
(d) revise[b]	47

Note.
[a] Renamed or scope extended activity.
[b] New activity.

5.2. Synthesize information

The "synthesize information" activity phase focuses on reaching an integration of the processed pieces of information and prior knowledge. This phase also comprised four activities: one existing, one renamed, and two new activities. The diversity of observed strategies for "compare and contrast information" prompted its addition as a distinct activity. Additionally, the original "elaborate" activity was divided into "integrate information" and "elaborate on content" to conceptually distinguish between the integration of existing information and the addition of new insights or prior knowledge. Fig. 3 presents the strategies observed during this phase.

Compare and contrast. Within this activity, participants highlighted similarities and differences between different pieces of information. They often used multiple browser tabs to compare sources: "*… then I go browsing […], and then it stays open, and then I go to another link*

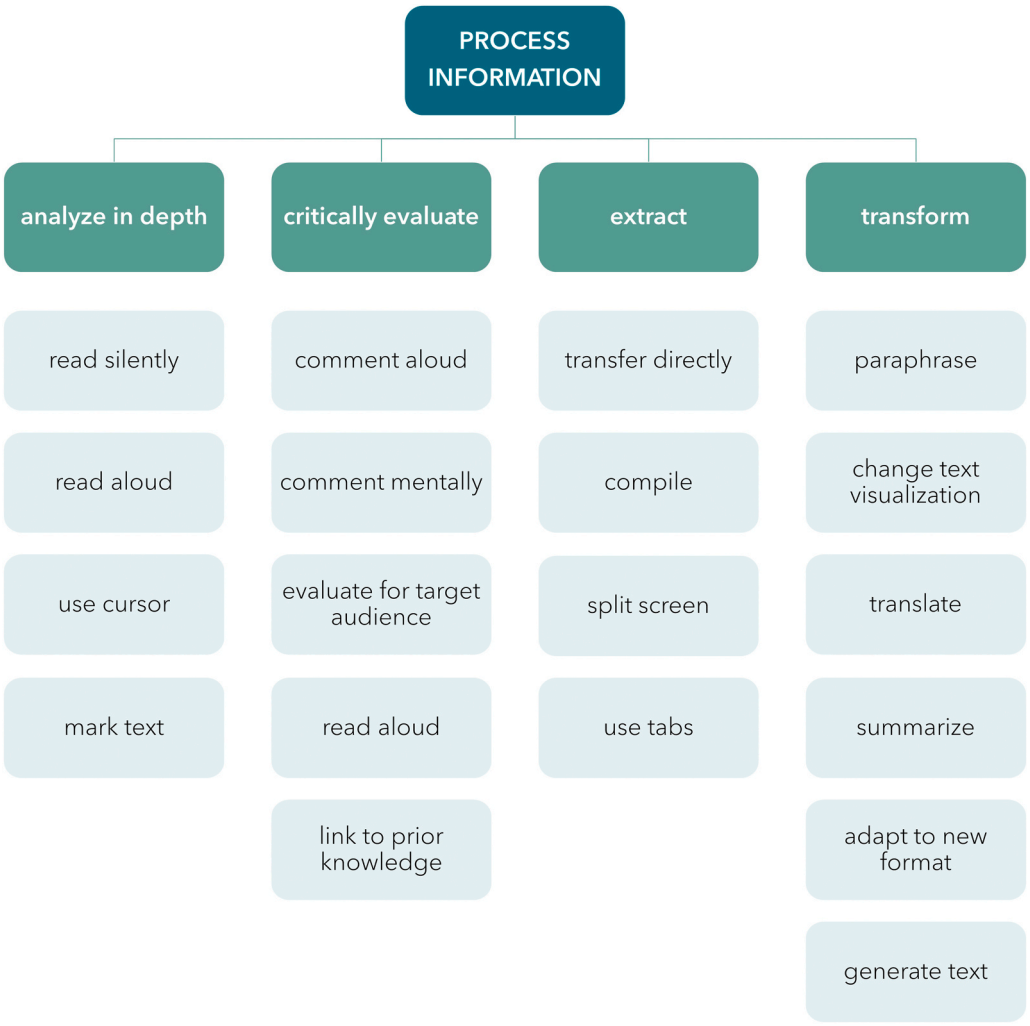

Fig. 2. Observed strategies during the "process information" activity phase, Ordered from High to low frequency.

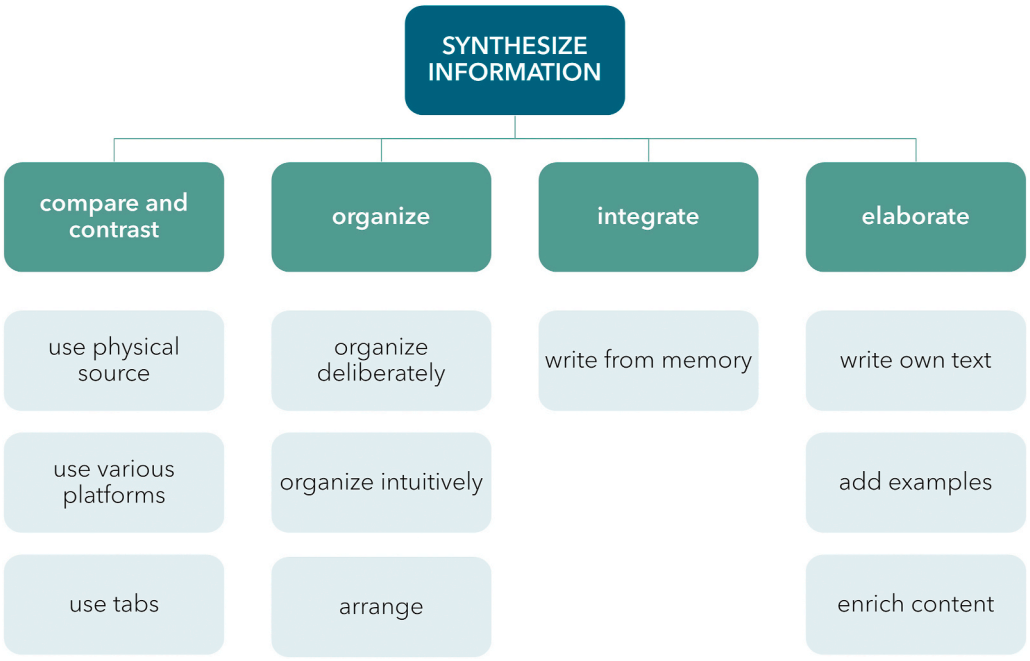

Fig. 3. Observed strategies during the "synthesize information" activity phase, Ordered from High to low frequency.

[…] just to make comparisons" (P17). Additionally, participants placed physical information sources such as books on their desks to compare with online information. Moreover, a few participants also used different search platforms to compare information, as P19 noted: "*[next to Google] I was curious what ChatGPT had to say*."

Organize. This activity involved organizing the information logically to build a coherent narrative or argument. It was renamed from the original "structure relevant information" to encompass a broader range of strategies, including categorizing, sorting, and arranging information. Participants often organized information through deliberate reasoning: "*Then I thought: […] it is about why social interaction is important […] so that's why I think: I'll place it here*" (P6). Others organized more intuitively: "*Okay, let's put things that seem useful to me in terms of the order in which the text is read*" (P19). Sometimes, organization involved arranging existing information bits in a specific format: "*I wanted to add that sentence to my list […] In the end, I placed it with the first one*" (P14).

Integrate. This activity focused on combining various pieces of information to form a comprehensive picture. Notably, only three participants employed strategies for integration. They wrote texts shortly after reading various sources, relying on their short-term memory to integrate the information. As P23 explained: "*… in this case, it was based on multiple sources, just of my short-term memory, and then […] I just summarize it afterward in my own words.*" P8 described this strategy more figuratively: "*You put everything together, mash it up, and make a story out of it.*" These quotes highlight the participants' reliance on immediate recall and personal interpretation to create cohesive narratives from diverse information sources.

Elaborate. In this activity, participants enhanced the information they found by incorporating prior knowledge and new insights. This activity allowed for personal contributions and interpretations, adding value to the content. Most participants elaborated on the existing information by writing their own text: "*That one […] I wrote myself […] it's a bit of a summary of well: this is what he says, this is what 'Wij-Leren' [educational website] says*" (P21). They also frequently elaborated on the content by adding personal anecdotes or examples, as one participant explained: "*I don't want to just copy it. I wanted to show examples with materials we have at school and which I think at least one out of three parents have at home*" (P20). Moreover, several participants enriched existing content by adding information: "*… if I know that the students can handle it, I will add stuff […] because often the methods are very basic and then I notice: some students can handle this, and some don't*" (P15).

5.3. Create product

The "create product" activity phase focuses on developing the final product from the processed and synthesized information. Four activities were identified within this phase: one existing, two renamed, and one new activity. The activity "revise" was introduced due to its frequent occurrence and the absence of a suitable existing category. Although revising can be considered part of regulating the IPS process, it was explicitly included to account for the wide variety of revision strategies, critical for creating a high-quality final product. Fig. 4 illustrates the observed strategies during this phase.

Conceptualize. This activity involved translating task requirements into concrete ideas for the end product. In the original IPS-I model, this activity was named "formulate problem," but it was renamed to reflect participants' focus on linking the problem to their product better. Many participants defined the scope of their product by considering the target audience: "*If I […] look at my target audience, their concentration is indeed really this kind of piece of text […] so I don't want to write long pieces of text*"

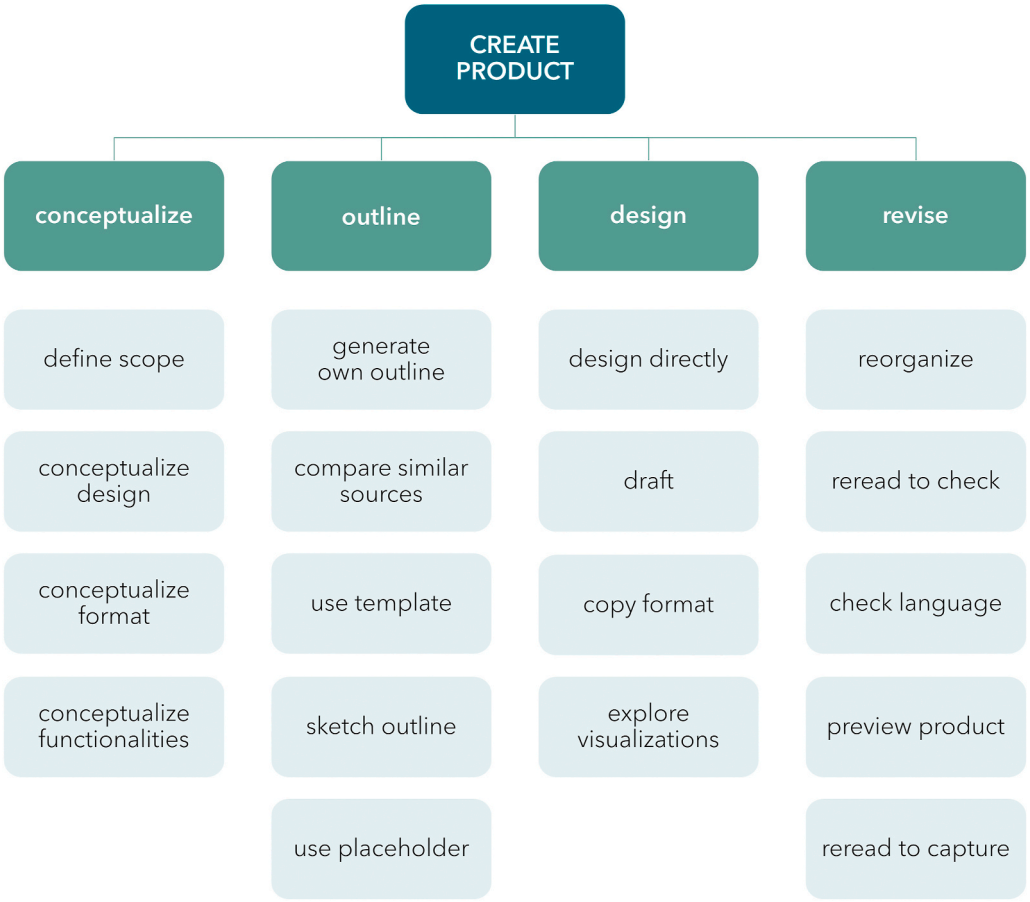

Fig. 4. Observed strategies during the "create product" activity phase, Ordered from High to low frequency.

(P23). Before creating the product, participants also conceptualized its design, format, and functionalities, either mentally or by using visualization strategies such as using a style board: "*The 'style board' […] that's where my use of color is specified and also my font*" (P6).

Outline. During this activity, students drafted a structured plan depicting the final product's key components and layout. Many participants created their own outline: "*I just wanted to make the skeleton […] because it helps me to determine: what do I want or what do I already have?*" (P10). Others principally looked at similar sources and copied their outline: "*I mainly followed the outline of the book Learner English*" (P25). Alternatively, several participants used pre-generated templates. When directly outlining on the website, some participants used placeholders to indicate the spots where specific parts would come: "*Then I already have a bit of a visual picture in my head of how I want it to look, so then I put [a placeholder] there*" (P20).

Design. In this activity, participants designed their final product using the processed and synthesized information. Participants designed their websites directly or created initial content drafts without bothering about the layout. P16 reported why she would incorporate the designing during the content creation: "… *I just have to adapt it immediately, because otherwise I'm afraid I'll forget it and then it just looks nice*" (P16). During this activity, they sometimes first explored visualization options: "*So I was playing around a bit with the sizes and the colors*" (P10) or copy-pasted a website section to replicate the same format. Other participants started with content drafts, leaving the layout for later: "*Just the broad outlines and then just slowly start filling in and then the whole layout, I think: "yes, that can also be done later*"" (P21). P21 also explained that he needed to know the content's size to make the design: "*to fit things nicely on the page … I don't want to do that until I know how big the content is*."

Revise. This activity included checking the content and revising the final product throughout the creation process. Participants utilized various strategies to revise their products, such as reorganizing, rereading, checking language, and previewing the product. For example, P17 reorganized the position of his texts: "… *yes, then I was over there […] when I thought: I think this one better goes down and that other one up.*" Additionally, participants reread sources either for capturing missed pieces of information or for in-depth content alignment checks: "*But is that really the case? Does he say that too? Let's look back, because … If I use it, I shouldn't say things he hasn't said*" (P21). Some participants split their screens to compare and check their content against the sources. They also checked the language of their text by using a spellchecker. Moreover, several participants previewed the initial design of their website to adapt the design or structure: "*That's why I always open the preview to see what does it look like for the student? […] Because then I can just click those elements and drag them*" (P24).

5.4. Co-occurring strategies

Participants used different patterns of co-occurring strategies. Three main patterns were identified: "reproductive," "arranging," and "elaborative." Table 3 presents an overview of these patterns of co-occurring strategies.

The first pattern, termed "reproductive," was characterized by participants approaching the task linearly, directly copy-pasting information and structure from the sources into their product with minimal transformation. Typically, these students split their screen to toggle between sources and their work. They directly placed and designed the copied information in their website and made minimal revisions, primarily for spelling at the end. P9 is an example of this pattern. This participant literally copied parts of a teaching textbook, including the formatting, to his website: "*[I italicized it] Because it's also italicized in the booklet […] you can make it recognizable like that [for my students]*" (P9). This pattern involved processing sources individually without integration or elaboration.

The second pattern, termed "arranging," involved participants using some transformation, structuring, and elaboration activities. They paraphrased information from sources and arranged it on their website mainly in a sequential manner. They often used a fixed template or order and displayed few elaborations. Revisions consisted mainly of checking language and re-reading to identify information overlooked from the sources. An example of this pattern is P14: "*I wanted to read the beginning and end again to find a sentence to add to my list.*" She extracted relevant parts from multiple sources by splitting her screen and copying them into her list in a *Word* document. She structured the relevant parts by arranging sentences from different sources into her list. She mainly added information that re-occurred over sources and included one item from her prior knowledge. This pattern thus mainly showed an arrangement of information with limited integration and elaboration.

The third pattern, termed "elaborative," was characterized by participants engaging more extensively in content transformation, integration, and elaboration. These participants created a unique final product based on a concept and outline they had developed themselves. Most of them continually drafted content and revised their work, comparing it with sources to ensure accuracy and coherence. For instance, P23 made summaries of several sources, paraphrased these, and then wrote texts from memory to integrate the information into a coherent text for her website. Her approach was more elaborate, adding unique elements relevant to her target groups, such as explanations and examples. She explained: "*I think that if I have the sources next to it […], I'm more inclined to […] almost completely take that over. And if I do [write] it on my own, then I immediately have a target group in mind faster, and then that immediately fits better with what I ultimately want to achieve with it.*" This quote indicates her intent to adapt and personalize the information, demonstrating a thorough elaboration on the content.

Table 3
Patterns of Co-occurring strategies for process, synthesize, and create.

Type	Ex.	Process Strategies	Synthesize Strategies	Create Strategies
Reproductive	P9	Reads sources mainly to extract. Directly copies information from sources with no or minimal transformation.	Uses unmodified information in the order it appeared in the sources, without integration and elaboration.	Follows outline from a template or similar sources. Revises mainly to check language and design.
Arranging	P14	Reads sources mainly to extract. Evaluates if source matches prior knowledge. Compiles information with some transformations.	Compares information to extract reoccurring elements corresponding to prior knowledge. Structures information by juxtaposing, with limited integration and elaboration.	Uses template or own outline. Revises spelling and design, and sometimes content and structure. Rereads mainly to capture missed information.
Elaborative	P23	Analyzes sources in depth. Critically evaluates information thinking of own product. Transforms information extensively.	Organizes and integrates information from multiple sources and elaborates extensively.	Creates product based on an elaborate original concept and self-devised outline while continually revising work against original content to ensure accuracy and coherence.

6. Discussion

Relatively little research has focused on the phases of "process" and "organize and present" online information during authentic IPS tasks. Most previous studies have focused on the "search" and "select" phases of simple, short-duration IPS tasks, which do not reflect the complex information challenges students will face in professional settings after graduation (Garcia & Badia, 2017; Walton & Hepworth, 2011). This study addressed this gap by exploring students' strategies for processing and presenting information during a semester-long authentic IPS task of creating a website for professional practice. The in-depth examination of specific IPS phases during a whole IPS task offered a detailed understanding of students' current strategies. Through thematic analysis, students' strategies were categorized into twelve activities across three activity phases: "process," "synthesize," and "create." Within these phases, three patterns of co-occurring strategies were observed: reproductive, arranging, and elaborative.

This study contributes to the literature in two ways. The results highlighted the need for task-specific adjustments to the IPS-I model. Therefore, the study proposes an empirically grounded, adapted IPS model tailored to the context of an authentic IPS task. Additionally, the study provides detailed insights into how students operationalize the "process" and "organize and present" activity phases of IPS. Unlike many previous studies that focus on deficiencies (e.g., Argelagós & Pifarré, 2016; Rosenblatt, 2010; Walraven et al., 2008), this qualitative study emphasizes students' strengths and the strategies they already possess. This strengths-based perspective is crucial for educators in designing instructional interventions that enhance students' existing information processing and presentation competencies. By offering a deeper understanding of how students manage professionally oriented IPS tasks, the findings help bridge the gap between current student experiences and their preparedness for future professional IPS challenges.

6.1. Strategies for processing, synthesizing, and creating information

The analysis revealed a noteworthy variation in the strategies employed by participants across different phases of the IPS task. This wide range of strategies illustrates that there is no single "right way" to approach authentic, open-ended IPS tasks. It also shows that participants already possess various strategies that can be expanded upon.

In the "process information" phase, participants exhibited a variety of strategies with differing levels of depth in processing. Half the participants did not use transforming strategies, simply extracting information into their product without adapting it. This aligns with previous research showing that students often copy and paste information from digital sources without transforming it (e.g., Azevedo et al., 2004; Probert, 2009). This behavior reflects surface-level processing, indicating a lack of critical interaction with the material. The other half of the participants demonstrated more active transformation by adapting textual information to suit their target audience. They engaged in deeper processing by compiling, paraphrasing, and critically checking their content against the sources. Such strategies are indicative of deeper learning processes, which are generally associated with better student learning outcomes (Biggs, 1996). For these participants, the task-specific context appeared to have fostered more elaborate transformation strategies, suggesting that authentic tasks can promote more in-depth processing of information sources. However, the persistence of direct copying in others indicates a need for guidance in open-ended tasks to encourage deeper processing strategies for all students. The different patterns associated with the depth of processing will be discussed in more detail in section 6.2.

During the "synthesize" phase, participants demonstrated fewer instances of explicit strategies compared to the "process" and "create" phases. For integrating information, only three participants used the strategy of reading several sources and then writing from memory shortly after. Mapping techniques such as mind mapping or concept mapping were not observed, although these are effective strategies for integrating information from various sources (Ginns, 2006; List, 2019; Schroeder et al., 2018). This finding aligns with previous research, showing that students often struggle to connect information from multiple texts, focusing more on gathering facts than synthesizing them (Bennett et al., 2008; Mateos & Solé, 2009). The observed elaboration strategies mainly involved adding examples or original texts to existing content. However, these additions were predominantly based on prior domain knowledge rather than a genuine integration of personal insights connected to existing sources. The limited use of explicit strategies in this phase could impact the quality of the final product, as effective integration strategies are essential for successfully completing IPS tasks (Rouet, 2013; Wiley et al., 2009).

Students generally devoted the most attention to the "create" phase, employing a wide array of strategies. This aligns with the findings of Brand-Gruwel et al. (2005), who found that both experts and novices invested substantial time in presenting information. Some participants opted for straightforward methods, such as following an existing template without modifications or duplicating the outline of similar products. This reliance mirrors findings by Solé et al. (2013), where students often replicated the structure and order of source texts when writing a synthesis text. Other participants developed unique concepts and outlines tailored to specific task requirements, adapting existing templates and using similar sources mainly for design inspiration. Similarly, while some participants limited their reviews to basic checks for spelling and design, others undertook comprehensive reviews, revisiting sources to ensure content accuracy and depth. This variation in the depth of strategies underscores the need to foster deeper engagement throughout the creation of the final product.

6.2. Co-occurring strategies

Three patterns in co-occurring strategies were classified: reproductive, arranging, and elaborative. The patterns illustrate how participants interact with information at various levels, transforming, integrating, and elaborating to different degrees. The reproductive pattern, characterized by direct copying with minimal transformation, aligns with Priemer and Ploog's (2007) concept of "compilers," indicating a surface-level processing of the information. Similarly, Sole et al. (2013) found that reproductive patterns involved very few integrations. This pattern may be explained by a lack of motivation, which affects the depth of processing (Pifarré & Argelagós, 2020), limited prior knowledge, which impacts the ability to effectively integrate information (Argelagós et al., 2022; Frerejean et al., 2016), or a limited repertoire of strategies. Consequently, this pattern could result in final products that are technically complete but lack depth and originality and may violate copyright rules.

The arranging pattern involved some transformation and structuring but still showed limited integration and synthesis, similar to the "juxtaposed summary" pattern identified by Sole et al. (2013). Participants using this pattern extracted information from multiple sources, compiled it, and arranged it often using a fixed template or order. For instance, they identified recurring information across sources and organized it into bullet lists. These participants primarily used rereading to capture additional ideas from source texts, which they then positioned with in their own writing. This pattern demonstrates a step beyond mere reproduction, as participants engaged in some level of cognitive processing. However, the focus on arranging rather than deeply integrating information also highlights the challenges these participants faced when attempting to synthesize complex information meaningfully.

The elaborative pattern demonstrated extensive transformation, integration, and elaboration, similar to Priemer and Ploog's (2007) concept of "authors." Participants exhibiting this pattern created unique final products based on self-developed concepts and outlines. They engaged in drafting and revision, comparing their work with sources to

ensure accuracy and coherence. For instance, one participant made summaries of several sources, paraphrased these, and then wrote texts from memory to integrate the information coherently. This pattern involved adding unique elements relevant to target groups, such as explanations and examples, demonstrating a thorough elaboration on the content. The elaborative pattern was only observed in only a few participants. This indicates a need for instructional strategies that promote more critical engagement with content, encouraging students to move beyond mere arrangement to meaningful integration of information.

6.3. Theoretical implications

The categorization of the observed IPS strategies into activities and activity phases has significant implications for the IPS-I model as initially proposed by Brand-Gruwel et al. (2009). The wide variety of strategies observed within the "process" and "organize and present" phases highlighted the need for clearer conceptual separation between these phases. Consequently, this prompted the introduction of adapted activity phases: process, synthesize, and create information. Fig. 5 presents an updated model of the six activity phases of the IPS process, integrating these adapted activity phases into the original IPS-I model.

The most essential alteration in the model is the addition of "synthesize" as a separate activity phase. This change conceptually separates processing individual pieces of information during the "process" phase from their integration during the "synthesize" phase, which is then used for creating a product in the "create" phase. In the original IPS-I model, activities related to the combination of information and product creation were intertwined within the single "organize and present" activity phase. While "organize and present" was considered the synthesis part of the IPS process (Brand-Gruwel et al., 2005, 2009), this study suggests considering synthesis as a separate activity phase, distinct from final product creation. This separation aligns with other IPS models, such as the Big6 (Eisenberg & Berkowitz, 1990), which distinguishes the synthesis of information from multiple sources from the presentation of the product. Previous research using the IPS-I model has also suggested "synthesize information" as a separate activity within the "organize and present" phase (e.g., Frerejean et al., 2016; Pifarré & Argelagós, 2020). Our findings empirically support that "synthesize" comprises more than a single activity: it can be considered a conceptually distinct activity phase comprising several activities.

Additionally, the findings of this study provide empirical support for several new activities within the three phases of "process," "synthesize," and "create," as detailed in Table 2. Newly identified activities include "transform information," "integrate information," "conceptualize final product," and "revise product." This study also empirically confirms the importance of "extract relevant information" and "compare and contrast information," activities previously proposed in research (e.g., Frerejean et al., 2016; Pifarré & Argelagós, 2020).

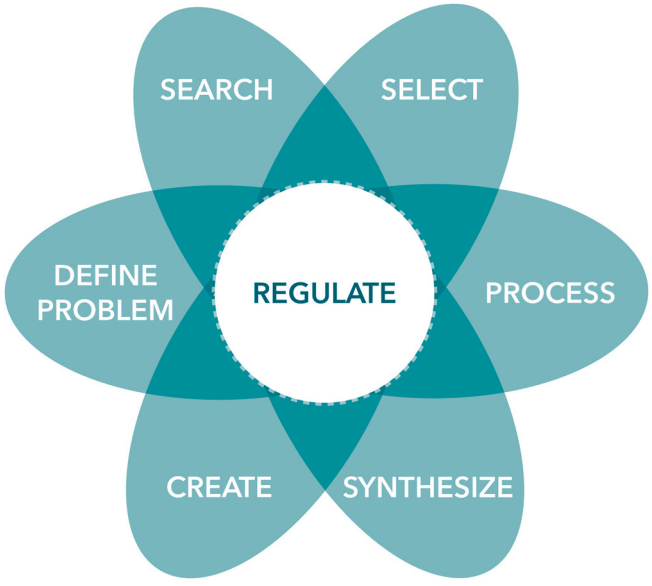

Fig. 5. The six interrelated activity phases of the iterative information problem solving process (adapted from Brand-Gruwel et al., 2009).

These adaptations of the original IPS-I model highlight the importance of task context in the IPS process. While Brand-Gruwel et al. (2005) posited that the IPS process is similar for different forms of products, specific adaptations were necessary to fit the task of creating an educational website. These differences may stem from the fact that the original IPS-I model was based on short, academically oriented, written tasks. In contrast, this study examined a semester-long task of creating a multimedia website. As a result of the length and complexity, participants were required to use more elaborate strategies within the "process," "synthesize," and "create" phases. Thereby, the results align with the strategic learning perspective, showing that IPS activities vary depending on the task's specific characteristics (Becerril Balín & Badia Garganté, 2013; Monereo & Badia, 2012). This finding suggests that the IPS-I model should be seen as flexible and adaptable, with different tasks potentially revealing different aspects of the IPS process.

Moreover, the findings provide valuable insights into how authentic, whole tasks influence students' IPS processes. Prior research has shown that using authentic tasks and embedding these in the curriculum generally positively affects students' IPS learning outcomes and their transfer (e.g., Argelagós et al., 2022; Frerejean et al., 2019). For example, education students who produced informational brochures on dyslexia as part of a course demonstrated improved IPS performance relative to peers who did not perform this learning task (Brand-Gruwel et al., 2006). This study builds on these findings by uncovering students' learning processes during such tasks, potentially explaining their effectiveness.

In response to the authentic, complex, open-ended task, students employed a range of strategies and activities. Students could not simply follow a linear "recipe," as authentic tasks do not have a single correct solution path. This prompted students to adopt an iterative approach rather than following IPS phases sequentially, aligning with the iterative IPS-I model as proposed by Brand-Gruwel et al. (2005, 2009). For instance, many students began conceptualizing or outlining their website before processing the information. This non-linear progression mirrors the real-world IPS challenges students will face after graduation. The variety and iterative nature of approaches suggests that authentic tasks encourage students to make deliberate choices, tailoring their IPS strategies to the specific demands of the task. This flexibility and adaptability likely contribute to the improved IPS competence and transfer observed with authentic tasks.

6.4. Instructional implications

The findings of this study offer several instructional implications for developing IPS competence in higher education, particularly for professional purposes. Implementing these instructional guidelines can create a more supportive and effective learning environment, equipping higher education students with the necessary strategies to meet the challenges of professional practice.

First, the results indicate that students already possess a variety of IPS strategies even without explicit instruction. Educators can build upon these existing strategies to further extend students' strategic repertoires. The observed diversity of strategic patterns suggests that instruction should encompass multiple strategies for each IPS activity rather than promoting a single "correct" method. One effective way to achieve this is through modeling (e.g., Frerejean et al., 2018; Tewell, 2014). Observational learning from model demonstrations enhances the acquisition of complex competences by revealing the underlying cognitive processes involved (Bandura and Walters, 1977), making it a

suitable method for teaching IPS strategies. Peer modeling, in particular, has shown positive effects on IPS performance in previous studies (Frerejean et al., 2018; Mateos et al., 2018). Demonstrating various strategies helps students broaden their strategic repertoire and learn when and why to apply them. This approach aligns with the strategic learning perspective, emphasizing the need to provide students with a range of strategies to meet individual needs and task demands.

Second, given the iterative nature of IPS activities observed, a whole-task approach is recommended for IPS instruction. This method enables students to integrate and coordinate different IPS activities, starting with simpler versions of the authentic task and gradually increasing complexity (Van Merriënboer, 1997). Previous studies have found positive effects of whole-task instruction on developing IPS competence (Argelagós et al., 2022; Frerejean et al., 2019). Through whole-task instruction, students repeatedly practice the different phases of IPS within a meaningful context. Emphasizing different activity phases at various stages of training can further enhance learning outcomes. The addition of the "synthesize information" phase in the adapted IPS-I model suggests the need to emphasize this complex IPS phase. Repeated practice and emphasis on the different phases of a whole task, including the complex "synthesize information" phase, is necessary for fully developing IPS competence.

Third, the results show the influence of the task context and interpretation on the strategies and activities used. The type of educational website they created determined the variety and number of online sources they used. For example, students making websites for younger children relied mainly on prior knowledge, whereas others creating informative websites for adults integrated information from multiple online sources. The choices made within the open-ended task influenced the type and amount of processing and synthesis activities used. This variation highlights the importance of practicing IPS instruction within varied task contexts. Van Merriënboer (1997) argues that complex cognitive competences should be trained in as many contexts as possible to stimulate transfer to new situations. When teaching strategies for different IPS tasks, it should be made explicit to students that a strategy effective in one task may or may not work for another. Emphasizing these strategic and heuristic aspects of IPS can help students transfer the learned IPS strategies for effective performance in various task contexts.

6.5. Limitations and future research

While this study offers important insights into the IPS processes among higher education students, it is subject to several methodological and contextual limitations that might influence the interpretation and generalizability of the findings. These limitations include issues related to ecological validity, construct validity, reliability, and external validity.

Concerning ecological validity, this study observed a subset of a semester-long authentic IPS task, providing a valuable snapshot of IPS strategies used. However, the limited number of integration activities observed suggests that the snapshot did not capture all strategies. Participants who prepared beforehand by reading sources and taking notes may have integrated information in ways that were not explicitly visible during the screencast. In contrast, participants who did not prepare beforehand were often still in the initial task stages, focusing mainly on searching information rather than processing and presenting it. Nonetheless, this situation reflects real-world student behavior, as students often begin large tasks late and may not always be fully prepared. Despite this limitation, the study revealed that even participants in the early task stages engaged in activities from the "create" phase, such as conceptualizing and outlining their final product. This finding underscores the iterative nature of IPS and suggests that structuring the product early can help manage complex IPS tasks. Future research could build on these findings by randomly observing students at different times during long-term IPS tasks to expand the strategies used at different task stages.

Regarding construct validity, while the study identified various strategic patterns, these were not linked to the quality of the final product. Although more integrative and elaborative strategies may be associated with higher-quality end products, this study did not conclusively demonstrate that association. The limited observation of integration strategies may be attributed to participants' choice of familiar topics, potentially reducing the necessity for explicit integration. An alternative task requiring more explicit use of sources might reveal additional strategies. Additionally, the thematic analysis lacked quantitative data on strategy duration, limiting understanding of their effectiveness. This highlights the need for future research to develop fair and robust methods to evaluate the effectiveness of these strategies. Such methods should examine the relationship between the type and duration of strategies used and the quality of the final product—considering aspects like processed information, synthesis level, and presentation. This will provide deeper insights into what constitutes effective strategies that result in high-quality products.

In terms of reliability, the use of cued retrospective reporting aimed to provide a less obtrusive method for observing students' cognitive processes compared to concurrent think-alouds. However, student awareness of the direct observation by the researcher could have subtly altered their behavior. In addition, using a verbal protocol might have limited our observation of integration strategies, as these processes might occur internally and not be verbalized. Future research should explore even less intrusive observational methods, such as eye-tracking, which can capture unconscious or automated strategies that verbal protocols might miss. Additionally, representational tools could be used to observe and clarify the often-hidden synthesis processes, providing a more comprehensive understanding of IPS activities (e.g., Kiili & Leu, 2019).

Addressing external validity, the study's focus on a specific target group (pre-service teachers) and task (website creation) allowed for a close examination of the concrete IPS activities and strategies involved in an authentic educational context. At the same time, this specific context might limit the generalizability of the findings. Although the diversity of participants across different educational specializations helps mitigate some concerns about representativeness, the findings may not extend to other professional domains. Despite this, the proposed updated IPS model offers a valuable framework for future studies. Future research could validate and expand upon the proposed model by comparing the observed IPS activities in different authentic tasks and educational contexts. Additionally, investigating the impact of emerging technologies, such as generative AI, on IPS activities could provide valuable insights into how these tools influence strategy selection and task execution in professional environments. These validations of the IPS model are essential to ensure its continued relevance in diverse educational and professional contexts.

6.6. Conclusion

This study explored the strategies employed by higher education students in a long-term authentic IPS task, specifically focusing on processing and presenting information. Through thematic analysis, a variety of strategies were identified and categorized into twelve IPS activities across three activity phases: "process information," "synthesize information," and "create product." Within these phases, three patterns of co-occurring strategies were observed: reproductive, arranging, and elaborative. By zooming into these specific activity phases, the analysis provided detailed insights that empirically refined the IPS-I model by Brand-Gruwel et al. (2009). The refinement involved adapting and identifying new activities, as well as modifying the original "process" and "organize and present" phases to include a "synthesize" phase.

The task-specific adaptations of the IPS-I model and the observed differences in strategic patterns highlight the dynamic nature of IPS competence within authentic tasks. In authentic, open-ended tasks,

strategies are not uniformly effective. Their relevance and effectiveness depend on the specific task requirements and the type of product made. This emphasizes the need to teach specific strategies and foster the ability to adapt these strategies to different tasks. Educational programs should, therefore, extend beyond teaching a standardized set of IPS strategies. Instead, they should foster strategic flexibility, enabling students to tailor their strategies to various authentic task contexts. This strategic flexibility is key to ensuring that students are well-prepared to face the diverse and complex IPS tasks they will face in their future careers.

In conclusion, this study contributes to the theoretical understanding of IPS for authentic tasks and can help educators enhance students' existing strategies. Future research should build on these findings, exploring the applicability of the updated IPS-I model across different authentic tasks in varying domains within higher education.

Ethics statement

No funding was received to conduct this study.

The University of Applied Sciences Utrecht's ethics board granted ethical approval. The study was performed in accordance with the Netherlands Code of Conduct for Research Integrity 2018; KNAW et al., 2018), and informed consent was obtained prior to its commencement.

Data statement

In accordance with common open science practices, we provide all datasets and data analysis files online. For those participants who consented to have their data shared for research purposes, data is available at: http://doi.org/10.17605/OSF.IO/E9P3K.

The full dataset, including data from participants who did not consent to have their data shared in a research repository, is available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Josien Boetje: Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Stan O. van Ginkel:** Writing – review & editing, Supervision, Methodology. **Matthijs H.J. Smakman:** Writing – review & editing, Supervision, Methodology. **Erik Barendsen:** Writing – review & editing, Supervision. **Johan Versendaal:** Writing – review & editing, Supervision.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT and Grammarly to improve language and readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chbr.2024.100470.

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