

# gStudy traces of children's self-regulated learning in the Lifecycles Learning Kit

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## Abstract

Evidence is accumulating that young children engage in self-regulated learning (SRL). One challenge is obtaining valid and reliable measures of children's SRL. The gStudy software and its associated Learning Kits hold promise in this regard. We used gStudy to trace grade 1 children's SRL as they studied the lifecycle of frogs in the Lifecycles Learning Kit (LLK). Children studied two interactive information texts that described the lifecycle of frogs and provided opportunities for SRL. After reading each text, children completed note templates configured for recording observations, asking questions, making predictions, and self-evaluating learning. Finally, they used gStudy's concept mapping tool to group key concepts across texts. gStudy traces of children's SRL, responses to comprehension questions, observation logs, self-evaluation templates, and concept maps were analyzed for evidence of (a) what children learned and (b) how they regulated learning. Results indicated participants achieved high text-based comprehension and high SRL. Also, statistically significant positive correlations existed between teachers' ratings of students' achievement and students' achievement on LLK tasks, and between students' SRL in the LLK and their achievement on LLK tasks. Children reported high motivation for studying with the LLK. Qualitative analyses of children's observation logs and concept maps reveal their depth of understanding.

Key words: self-regulated learning, motivation, text comprehension, children, observation logs

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Self-regulated learning (SRL) involves metacognition, motivation for learning, and strategic action (Winne & Perry, 2000; Zimmerman, 1990; 2008). Self-regulated learners use *metacognition* to analyze task demands in relation to personal strengths and weaknesses, and then regulate behaviour to optimize learning processes and products. They demonstrate *motivation for learning* when they focus on progress and deep understanding; attempt challenging tasks that afford occasions to develop new skills; and view errors constructively – as opportunities for learning. Finally, *strategic* describes how self-regulated learners choose and apply effective learning and problem solving strategies that suit tasks and their learning profiles. Together, these academically adaptive attitudes and actions enable children to acquire knowledge and skills that benefit them in and beyond school.

Although the preponderance of research on self-regulated learning (SRL) continues to involve learners in the intermediate grades and beyond, research that examines young children's engagement in academically effective forms regulation while learning is accumulating (Graziano, Reavis, Keane, & Calkins, 2007; Perry, 1998; Perry, VandeKamp, Mercer, & Nordby, 2002; Turner, 1995; Whitebread, Bingham, Grau, Pino-Pasternak, & Sangster, 2007). This research provides evidence that young children can and do regulate learning (e.g., they plan and monitor progress, apply effective strategies to solve problems, and evaluate outcomes). Much of this research highlights the need for researchers to attend to features of learning contexts, such as tasks and instrumental supports, and methods of measurement in studies of young children's regulation of learning.

## Tasks

Perry's research (e.g., Perry, Phillips, & Dowler, 2004; Perry, Phillips, & Hutchinson, 2006) has found consistent and robust associations between features of task environments and opportunities for children to develop and engage in SRL. In particular, complex, meaningful tasks, which address multiple goals, focus on large chunks of meaning, and extend over long periods of time, tend to provide opportunities for children to think metacognitively and behave strategically. Typically, they engage learners in a wide range of processes and allow for the creation of diverse products as evidence of learning. Also, most children find complex tasks intrinsically, or at least situationally, interesting (Renninger & Hidi, 2002). Both forms of interest are associated with motivation for learning. Complex tasks address children's learning and motivational differences by creating spaces for multiple zones of proximal development and customizing support for individuals (Brown & Campoine, 1994; Englert & Mariage, 2003). Finally, succeeding at complex tasks is associated with increased self-efficacy (McCaslin & Good, 1996), because such tasks tend to be challenging.

Complex tasks often are manifest in projects or integrated units of study (e.g., Perry, 1998; Perry et al., 2002). They are characteristic of inquiry and problem-based approaches to learning (Samarapungavan, Manizicopoulos, & Patrick, 2008), so science is a domain that lends itself to designing complex tasks. For example, in a previous study, Perry and colleagues observed children in grades 1 through 3 (ages 6-8) doing research

on animals. Teachers' designed these projects to address multiple goals, including: (a) learning to do research; (b) distinguishing factual from fictional texts; (c) learning to write expository text; (d) learning to edit; (e) learning to use the computer as a tool for writing; and (f) learning about animal habitats, eating habits, babies, and enemies. To accomplish these goals, children engaged in a variety of processes (e.g., information seeking and sorting; planning for writing, writing, and revising) and with variety of resources, including the Internet. Also, they produced a variety of artefacts to demonstrate their learning (e.g., written reports, illustrations, diagrams, models). Importantly, children had opportunities to control challenge by choosing "just right" materials, setting realistic goals, and collaborating with or seeking help from peers.

Similarly, Samarapungavan et al. (2008) used a guided inquiry approach to study kindergarten children's understandings of living things and their characteristics. They designed tasks and activities that afforded children opportunities for constructing, evaluating, and refining or reconstructing models of the lifecycle of the monarch butterfly. This unit of study lasted between 6 and 8 weeks, so it provided children with opportunities for sustained inquiry. Also, although teachers designed the overall framework for this investigation, they provided opportunities for children to choose what topics they wanted to explore, what they wanted to observe and record, and what conclusions to draw from their investigations. Children kept records of the monarchs' growth by drawing, taking digital photographs, and writing in notebooks. Also, they discussed, reflected upon, and summarized what they learned in small groups, and then the groups created posters to share their models of the monarch lifecycle with the class. All artefacts were entered in electronic portfolios, creating a comprehensive data base from which researchers could generate detailed descriptions of children's inquiry processes and the learning that resulted. In our study, children studied the lifecycle of frogs. We used *gStudy*<sup>3</sup> software to generate detailed accounts of children's learning and self-regulated learning as they studied the lifecycles of frogs.

### Opportunities and supports

Within complex tasks, children can be invited to regulate their learning by presenting them with opportunities to make choices and control challenges. When children have choices, such as what to produce, how to produce it, where to work, and with whom (as they did in our examples above), their interest and perceived competence for the task is increased (Turner, 1997; Turner & Paris, 1995), and they are more likely to increase effort and persist when the work is challenging. Moreover, creating opportunities for children to make choices within tasks invites them to think metacognitively about their strengths and weaknesses as learners, the task demands, and what tactics and strategies

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<sup>3</sup> *gStudy*, now *nStudy*, software was developed in the context of *The Learning Kit Project* and is designed to collect detailed, time-stamped trace data about how students study while interacting with multimedia content, such as texts, graphics, and video clips (Perry & Winne, 2006; Winne, Hadwin, Nesbit, Kumar, & Beaudoin, 2004).

will lead to success (Perry et al., 2002). Choices also create opportunities for children to control challenge, by, for example, changing learning or task conditions to better suit their interests and abilities (Perry, 2004; Rohrkemper & Corno, 1988). Finally, involving children in setting evaluation criteria and self-evaluating their work gives them a sense control over assessment outcomes, which enhances their motivation to try challenging tasks (Paris & Ayers, 1994). Also, it prompts metacognition and strategic action because it requires learners to judge qualities of their learning processes and products and encourages adjustments in behaviors that will enhance them (Winne & Perry, 2000).

Children's regulation of learning within classrooms and complex tasks is almost never a solo activity. Typically, it is supported through co-regulation and collaboration. Co-regulation refers to the process by which teachers and peers provide instrumental and responsive scaffolding to help learners acquire skills and strategies associated with effective learning and SRL (McCaslin & Good, 1996; Perry & Rahim, in press; Whitebread et al., 2007). Co-regulation reflects a transitional phase in which learners gradually appropriate skills and strategies from more capable others by, for example, obtaining guidance and informative feedback while learning and problem-solving. Collaboration, or shared regulation (see Hadwin, Oshige, Gress, & Winne, 2010), refers to processes by which children collectively regulate activity (e.g., share ideas, compare strategies, identify each participants area(s) of expertise, distribute labour to address shared goals and create common products). In our study, children did not engage in shared forms of regulation, but opportunities to make choices and control challenge were embedded in our complex task, along with instrumental supports (to co-regulate learning), and opportunities to self-evaluate learning and SRL.

## Measures

Obtaining valid and reliable measures of young children's SRL is a big challenge for researchers (Winne & Perry, 2000). Self-report questionnaires have been the standard approach to measuring self-regulation and SRL. Perry and Winne (2006; Winne & Perry, 2000) have expanded elsewhere on the limitations of such measures for adequately capturing all that occurs when learners are engaged in SRL. Here we emphasize that some of these limitations are particularly salient in studies involving young children. For example, children have difficulty generalizing across both tasks and time to evaluate what their "typical" approach to a given situation would be (Turner, 1995), yet this is what most questionnaires ask them to do. Often children conflate intentions with actions (Paris & Newman, 1990). If their intention was to try hard and be a good strategy user, they are likely to rate themselves highly on questions that refer to effort and strategy use, even if their responses exaggerate what actually occurred. Such ratings reflect young children's natural and, some argue, adaptive tendency toward optimism and displaying positive response bias (Turner, 1995; Winne, 1997). Finally, children struggle with the language and response formats used on many self-report questionnaires (Cain & Dweck, 1995).

In contrast, when researchers use developmentally appropriate measures (i.e., targeting topics children value and using language and response formats that are familiar to them),

understandings about children's motivation and self-regulation are advanced (Cain & Dweck, 1995; Newman & Roskos, 1997; Perry, 1998; Turner, 1995; Whitebread et al., 2007). Observations have been particularly useful in studies of young children's SRL because they record "traces" of what children actually do, versus what they say they do, and have the advantage of tying behaviors directly to the contexts in which they occurred. Moreover, researchers can refer to traces during semi-structured, stimulated recall interviews to support children's reporting of their thoughts and actions (Perry, 1998; Perry et al., 2002; Pino-Pasternak, Whitebread, Coltman, Howe, Mercer, & Warwick, 2010).

Trace evidence can be found in samples of children's work (e.g., a semantic web may be evidence of planning for writing, a marked up text may offer evidence of monitoring and self-correcting) or recorded conversations as they collaborate on a task or project (e.g., if they discuss appropriate strategies for solving arithmetic problems). For our interests, traces can indicate cognitive and metacognitive process that children have automated or find difficult to describe. With the use of software, traces can be accurately time-referenced and, when gathered across time and tasks, mark typical and significant features of and patterns in children's engagement in learning. Finally, using software to collect trace evidence can be relatively unobtrusive, which increases the representativeness of the data. In our study, *gStudy* software was used to collect trace data of children's learning and SRL while studying the lifecycle of frogs.

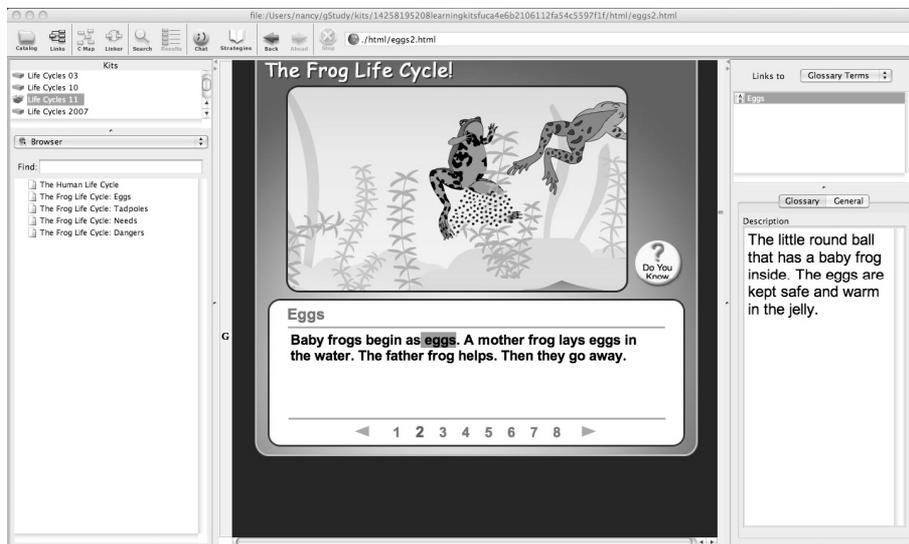
### **The Lifecycles Learning Kit**

The *Life Cycles Learning Kit (LLK)*, which was used in this study, was designed as a curriculum support for grade 1 and 2 children's learning about the lifecycles of frogs, and as a research tool to study young children's learning and SRL. It incorporates features of complex tasks (i.e., it addresses multiple goals and large chunks of meaning; engages children in a wide range of processes that lead to the production of many products; and, when implemented in classrooms as part of a larger unit on lifecycles, offers opportunities for sustained inquiry). It presents children with significant opportunities to engage in and enhance SRL (e.g., they have choices that enable them to control challenge and opportunities to monitor progress, evaluate learning, and seek help when they experience difficulty). Also, because studies of growth and change are part of the authorized science curriculum for early elementary grades in British Columbia, the content and tasks in the kit are consistent with what children and teachers are studying in their classrooms.

The LLK includes five interactive information texts describing the development of frogs from eggs to tadpoles to frogs, their needs for survival, and dangers they face. Within each text, key terms are highlighted and linked to dictionary terms that present definitions in the form of complete explanatory sentences (e.g., tadpole: A tadpole is a baby frog. It has no legs and looks like a little fish). A choice for children is whether to access a definition by double clicking on a highlighted term. Also within each text are "More" buttons and "Do You Know?" buttons. Children can access elaborated information by

clicking on the More buttons (e.g. a series of pictures that show how the eggs develop in jelly) and periodically check their understanding by clicking on the Do You Know? buttons. Clicking a Do You Know button opens a window with a multiple choice question. Children receive immediate feedback about whether their response is correct or incorrect and, if incorrect, are offered an opportunity to try again. Access to support accompanies this trial (e.g., children can ask for pictorial or textual hints). Figure 1 shows a page from one of the LLK texts. In addition to controlling the pace and direction with which they move through the texts (e.g., children can access particular pages or move linearly by pressing “Back” and “Next” buttons), these navigational features offer children choices that prompt metacognition (e.g., comprehension monitoring), motivation for learning (e.g., persisting to get the correct answer), and strategic action (e.g., adaptive help-seeking).

The LLK also includes “Observation Logs” that prompt children to record what they noticed as they studied frogs’ development (e.g., Tell how the tadpole grows and changes.), and to “Make Predictions” or “Ask Questions” about what they think will happen next. Self-evaluation templates include multiple choice questions for review and ask children to rate how sure they are about their answers. They include a list of LLK features for children to select those they used that day (e.g., I looked in the dictionary. I answered a Do You Know question). Calibration tasks such as these offer evidence of children’s metacognition (How accurate are their judgments of knowing and reports of learning tactics? Winne & Jamieson-Noel, 2002). Ratings of enjoyment for the work they’ve completed in the LLK are indicative of children’s interest, which is associated



**Figure 1:**  
Page from Eggs text in the Lifecycles Learning Kit.

with motivation for learning (Renninger & Hidi, 2002). Finally, a concept map allows children to arrange key concepts about the frog's lifecycle in a way that makes sense to them and shows what they have learned. Arranging frog/eggs/hatch/tadpole/ in a circle, for example, would suggest a well developed concept of the frog life cycle.

As children interact with texts and complete tasks, gStudy records what they do. For example, it traces the choices students make, under what conditions, and the effects of these choices on the overarching goal – to learn about frogs' lifecycles. These traces are targets for our assessment of children's SRL.

### **Overview of this study**

The main goal of this study was to examine children's SRL as they studied two of the information texts in the LLK. The selected texts covered content concerning all the phases in the frog's lifecycle and presented opportunities for children to regulate learning through comprehension monitoring (Do You Know?), adaptive help-seeking (asking for hints when they don't know an answer) and accessing elaborations (More and dictionary terms). Tasks included recording observations, asking questions or making predictions, self-evaluating learning, and representing learning in concept maps. Support for learning and SRL was embedded in these LLK objects and researchers were available to help with reading and recording information, and to provide technical support.

Three questions guided our analyses of the data:

- What did children understand about the frog's lifecycle?
- How did children regulate learning while studying with the LLK?
- How was children's SRL related to their understanding of the frog's lifecycle?

## **Methods**

### **Participants and setting**

Participants were 18 grade 1 children (10 boys) whose mean age was 7.02 years old ( $SD = .22$  years; Range = 6.52-7.37 years). Participants were selected from three classrooms in a high SES<sup>4</sup>, culturally and linguistically diverse school within a large suburban school district outside of Vancouver, Canada. Fifty percent of the children were from visible minority backgrounds. These classrooms were part of a larger study in which student teachers were being mentored to promote SRL (see Perry, Hutchinson, Thauberger, 2007; Perry, Phillips, & Hutchinson, 2006). Each of the classroom teachers in our study was a school-based mentor to a student teacher, and considered to be highly effective in supporting young children's engagement in SRL. All three teachers were female. The

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<sup>4</sup> Socioeconomic Status

school district serves a full range of learning, SES, and cultural backgrounds (33% of children speak English as a second language).

For this study, each classroom teacher was asked to nominate 6 of her students to participate in the study, equally distributed across the achievement range (e.g., 2 high, 2 average, and 2 low achieving learners). In addition, teachers and parents of participating children completed brief questionnaires that gauged the familiarity of children with computers (questionnaires are described below). Teachers were asked to report on: (a) children's access to computers in the classroom including the ratio of computers to children, and the types of computers available; (b) whether there was a computer lab at school; (c) approximately how much time the class spent per week working with computers in school; and (d) the nature of the computer activities at school (e.g., playing computer games, interacting with educational software). Two of the three teachers in this study had one PC computer in their classroom for approximately 20 children in the class, and all teachers indicated there was a computer lab in the school for the children to use. On average the three teachers reported that children spent approximately one hour per week working with the computers in school and their activities focused on honing typing skills, using word processing (e.g., Typing Tutor) and drawing software (e.g., Kid Pix), and accessing the Internet.

Similarly, parents were asked to report: (a) whether there was a computer in their home; (b) the average amount of time their child spent using the computer at home; (c) the nature of the computer activities the child engaged in at home; and (d) the extent of their child's interest in using the computer. Parents indicated that all children had access to computers at home, and on average spent approximately 3 hours and 20 minutes on the computer per week. Also, parents reported that children engaged in a wide range of activities/tasks related, including playing computer games (83%), using educational software (72%) and the Internet (44%), word processing (16%), and other activities (16%). Finally, parents reported that 95% of children were interested or very interested in the computer and had used it at home. These data made us fairly confident that children had reasonable exposure to computers that would prepare them to complete our tasks with gStudy.

## Data sources

*Teachers' ratings of children's academic achievement.* As indicated above, teachers were asked to provide a global rating of academic achievement for each child using a three point scale where 1 = low achieving, 2 = average achieving and 3 = high achieving. Standardized achievement data are not available for children in kindergarten through grade 3 in British Columbia, Canada. However, previous reviews of research have demonstrated the reliability of teachers' global ratings of students' achievement (e.g., Hoge & Coladarci, 1989; Llosa, 2008; Perry & Meisels, 1996).

*Teachers' ratings of children's motivation.* The Motivation Orientation Questionnaire (Perry, 1999) is a teacher-report measure that includes 20 statements. Ten statements describe behaviours associated with motivation for learning (e.g., "Seems motivated to

learn new things or improve skills for learning”; Item 13). Ten items describe behaviours associated with “self-handicapping” motivations (e.g., “Avoids or procrastinates on challenging tasks”; Item 3). Teachers rate each statement using a five-point Likert scale where 1 = not at all true of my student and 5 = very true of my student. The self-handicapping items were reverse coded and average scores for children’s motivation for learning were computed. Cronbach’s alpha for this measure was computed at .93.

*gStudy traces during reading in the LLK.* We collected trace data to examine what children were understanding about the lifecycles of frogs and how they were regulating learning while interacting with the LLK. As indicated above, traces are records of behavior, which can be used to infer SRL (e.g., aspects of metacognition, motivation for learning, and strategic action). Like all measures, they are imperfect representations of actual phenomena, but they are relatively unobtrusive, online measures that, especially with children, overcome many of the limitations of self-report questionnaires.

*Clicking the More and Do You Know buttons.* The LLK contains three “More” buttons (2 in the eggs text, 1 in the tadpoles text). These are hyperlinks that provide children with additional information (e.g., pictures/diagrams and text facts) about the eggs and tadpoles texts they study in the LLK. The More buttons offer children an opportunity to control challenge. Choosing more information could signal motivation for learning. Not choosing More information may reflect metacognition (e.g., recognizing and managing difficult material). The variable “more information” was computed by (a) examining traces from the log files and coding whether or not children accessed each of the More buttons (0 = did not click on the button, 1 = clicked on the button), and (b) summing these scores to compute a total score (out of 3) which represented the number of More buttons children accessed while studying the texts in the LLK.

There also are four “Do You Know” buttons (2 in the eggs text, 2 in the tadpoles text) that provide children with opportunities to monitor comprehension (e.g., “How does a tadpole change?”) as they study the eggs and tadpoles texts. Children who answer incorrectly have opportunities to persist to get the correct answer and can get help by asking for hints or acting on feedback. Each of these actions (checking comprehension, persisting when challenged, accessing help) are recorded by gStudy as evidence of SRL. We created the variable “do you know” by (a) examining traces from the log files and scoring whether or not children accessed each of the Do You Know buttons (0 = did not click on the button, 1 = clicked on the button), and (b) summing these scores to compute a total score (out of 4), which represented the number of Do You Know buttons children accessed while studying in the LLK. Also, children’s final answers to these questions were scored 0 for an incorrect answer and 1 for a correct answer. This comprehension score (out of 4) was combined with children’s post-reading comprehension score (also out of 4, see self-evaluation template below).

*Accessing the Dictionary.* The texts in the LLK included 23 highlighted dictionary terms that children could choose to study while reading the eggs and tadpoles texts. Ten of these terms also were used in the concept mapping activity (described below). Children could navigate to the dictionary at any point during their reading (e.g., to enhance their understanding of a concept or the text as a whole). We created the variable “dictionary”

by examining traces from the log files and giving children a score of 1 or 0 to indicate they did or did not access the dictionary while reading a text. These scores were summed across texts (out of 2).

*gStudy traces after reading in the LLK.* After reading each text, children completed observation logs and self-evaluation templates.

*Observation logs.* Children were provided with a question/prompt to guide their observations (e.g., "How do eggs/tadpoles grow and change?"). Children could record their observations by typing their answers into the text box that appeared below the question or dictating their response to the researcher who entered it in the text field for them (a choice that allowed children to control challenge).

*Coding children's observations.* Children's observations were coded according to four categories of information – text explicit (literal), text implicit (inferential), script implicit (going beyond the text; using prior knowledge), and incorrect (Pearson & Johnson, 1978; Vaughn & Bos, 2008) – to reflect children's understanding of the eggs and tadpoles texts. For example, observing that "eggs have jelly around [them]" was coded as evidence of text explicit (te) or literal understanding because it is a close paraphrase of the text. Observing that "enemies don't like the jelly" was coded as evidence of text implicit (ti) understanding, an inference from text that read, "... the baby frog is safe inside the jelly" and later "it tastes bad." Observing that "everyday eating food is how they grow" was coded as evidence of a script implicit (si) understanding because there is no mention of this in the text, but it is a logical conclusion to draw from the information given. Finally, observing that "the jelly melts" was coded as a misunderstanding of what happens to the jelly around the eggs – it doesn't melt, it gets eaten – and was coded as incorrect information (ic). Once children's ideas were coded, we totalled the number of ideas within and across categories of understanding. A separate score was computed for incorrect ideas.

*Asking questions and making predictions.* After recording their observations, children were prompted to ask a question beginning with "I wonder ...?" or make a prediction about what would happen next with a sentence starter that read "I predict ...." Children could record their questions and predictions in text boxes that appeared below each prompt. As with the observation fields, children could ask for help with typing or ask the researcher to enter their responses in the text fields for them.

*Coding children's questions and predictions.* Children had two opportunities to ask questions and two opportunities to make predictions. gStudy recorded whether they took these opportunities and then we coded children's questions and predictions to reflect their: (a) congruence with the content of the texts (i.e., Were they text relevant? Manzo, Manzo, & McKenna, 1995), and (b) whether they introduced new information that went beyond the content of the eggs and tadpoles texts. Children received separate scores for congruence (0 = not congruent, 1 = congruent), and new information (0 = not new, 1 = new). For example, the child who asked, "I wonder when the frog turns into an adult?" after reading the eggs text, received a score of 1 for congruence and a score of 1 for new information, since the question included information that went beyond the content of the eggs text. The child who predicted "... [the egg] is going to turn into a tadpole" received

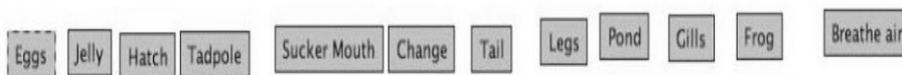
a score of 1 for congruence, but 0 for new information, since this information is provided in the text. The child who predicted “the eggs will turn into frogs” received a score of 1 for congruent information, but it would also be given a code of 0 because the information in the prediction is technically incorrect. Frogs turn into tadpoles before they turn into frogs. Finally, the child who asked, “Does the frog stay in the egg?” received a score of 0 for congruent information and 0 for new information because the information provided in the child’s question was both incongruent with information in the text and incorrect. Total number of congruent questions and predictions were summed within and across texts.

*Self-evaluation templates.* Children completed two self-evaluation templates, one for each text. Each self-evaluation template was divided into three sections. In the first section, children were asked to respond to two comprehension questions, like those linked to the Do You Know buttons in the text, and then to rate how sure they were that their response to the question was correct (1 = not sure, 9 = very sure). Children’s actual scores (correct or incorrect answers) were compared to their confidence ratings and provided a measure of calibration (judgment of knowing), which requires metacognitive monitoring (Garavalia & Gredler, 2002; Winne & Jamieson, 2002). Children who gave a correct answer and rated themselves as relatively sure (a rating of 6 or higher) received a score of 1, indicating they were well calibrated. Children who gave incorrect answers and rated themselves as relatively unsure (a rating of 3 or lower) also received a 1 indicating they were well calibrated. However, children who gave incorrect answers but rated themselves as relatively sure of their answers, or gave correct answers but rated themselves relatively sure received a 0 indicating they were not well calibrated. Children’s comprehension and calibration scores were summed across the two self-evaluation templates for a score out of 4.

In the second section of the self-evaluation template, children were asked to report which features of the LLK they used while studying that day by responding “Yes/No” to five statements in the form, “I looked in the dictionary.” These self-reports were compared with gStudy’s traces of their actual study behaviors, providing an additional measure of calibration (out of 6 across the two templates). Finally, the third section of the self-evaluation template asked children how much they enjoyed working with the LLK as an indication of their motivation for learning. Children rated their enjoyment on a 9-point scale. Children’s ratings of enjoyment were averaged across the two LLK texts.

*Concept maps.* The concept mapping task is a summary task, used to analyze children’s understandings of four main ideas relating to the lifecycles of frogs (e.g., ideas relating to growth and change, needs for survival, and the frog’s lifecycle). Children were presented with a screen containing 12 key concepts (the dictionary terms) from the texts: frog, hatch, eggs, tadpole, sucker mouth, jelly, gills, tail, change, legs, pond, breathe air. Children were instructed to organize the concepts in a way that made sense to them. They could rearrange the concepts by dragging/moving them on the screen. When they were finished organizing the terms, a researcher asked them to explain their organization of terms with the request, “Can you tell me why you put them in that group?”

*Coding children’s concept maps.* Children’s concept maps and explanations were coded for evidence they were representing or mentioning three main ideas about lifecycles in general and, more specifically, about the lifecycles of frogs. Children received 1 point for including ideas relating to how baby frogs grow and change, 1 point for including ideas relating to their survival needs, and up to 4 points for their representation of the cyclical phases in the frog’s lifecycle: frogs lay eggs (1), eggs hatch to become tadpoles (1), tadpoles become frogs (1), and frogs lay eggs (1, completing the cycle). These ideas were summed across children within categories. Incorrect ideas also were coded. Figure 2 shows one child’s concept map. This child received 1 point for ideas relating to growth and change, and 2 points for representing two phases of the lifecycle, “Then they hatch and ... become ... tadpoles ... and then they turn into a frog ...”



S4: It’s because first they go into eggs and they go into jelly... then they hatch and then they become... uh...tadpoles... and then they have a ... sucker mouth ... and then they change and then they get a tail and then legs ... and I don’t know why pond is there. I just put it there... and they get gills and then they turn into a grog and then they breathe air.

Student	Idea 1	Idea 2	Idea 3	Incorrect	Category total	Total
4	1	0	2	0	2	3

**Figure 2:**  
A child’s completed concept map with transcription and scoring.

Evidence of children self-regulating learning while completing the concept mapping task was recorded and later coded inductively according to the specific nature of the regulation. Emerging categories reflected self-monitoring/self-evaluation and help-seeking. Instances of self-monitoring or self-evaluation were identified when children either pondered the need for a change to their organization of key concepts, or made a change. Researchers coded three actions in this regard: (a) children considered making a change, but didn’t make the change, and it was the right decision to make (i.e., their concept map was correct as it was); (b) children made a change and the change corrected an error or increased their overall score on the concept map; and (c) children made a change that was detrimental to their overall score on the concept map. Instances of help-seeking were coded in terms of the type of support requested. Four categories emerged from this analysis. Children asked for help with reading and finding information. Also they asked for technical support and grouping information. Instances of self-regulation were summed within and across categories.

## Procedures

Data were gathered over four days in June, 2007. Day 1 was an orientation to the LLK. Children completed an introductory lesson, reading the text about human babies, and were shown how to use the mouse and keyboard to navigate in the LLK (e.g., change views, access the dictionary, answer Do You Know questions). Children were encouraged to work independently, but were told that they could ask the researchers for help with navigation, reading or completing the observation and self-evaluation templates.

During Days 2 and 3, children studied the eggs and tadpoles lessons, respectively. During each lesson, children were asked by a researcher to read through the lessons, and that if they needed some technical or reading support they could ask the researcher for help. After children read, the researcher asked them if they were finished, and if so, they were asked to complete the observation and self-evaluation templates for the lesson. On Day 4, a researcher presented children with the concept mapping activity and demonstrated how to use the mouse to move concepts on the screen. The children were then asked to arrange the concepts on the screen to show their learning about the lifecycles of frogs. Children were also told if they needed help reading or technical support they could ask for help from the researcher. Once children were satisfied with the arrangements of the concepts on their map, they were asked to explain to the researcher how they had organized the ideas.

## Results

Results are presented in four main sections. The first section summarizes data from the teachers' ratings of children's academic achievement and motivation for learning. The remaining three sections present data that address our three research questions.

### Teachers' ratings of children's achievement and motivation

Although we asked teachers to nominate 6 children at each achievement level (high, average, low), they rated only four of the participating children as generally high achieving, six as generally low achieving, and eight as average achieving. None of the participants had designated exceptionalities, such as learning or developmental disabilities. Teachers' ratings of children's motivation indicated that, overall, children were motivated to learn ( $M = 3.65$ ,  $SD = .51$ ). Descriptive statistics for these data are shown in Table 1.

**Table 1:**  
Descriptive statistics for the Motivation, Comprehension, SRL, and Calibration Variables (N = 18)

Variable	<i>M</i>	<i>SD</i>	Range	Students scoring above 50%
Motivation questionnaire	3.65	.51	3-5	<i>n</i> = 16
Comprehension questions (out of 8)	6.51	2	2-8	<i>n</i> = 14
SRL moves (out of 11)	6.44	2.31	2-9	<i>n</i> = 11
Calibration (out of 10)	8.50	8.5	3-10	<i>n</i> = 17

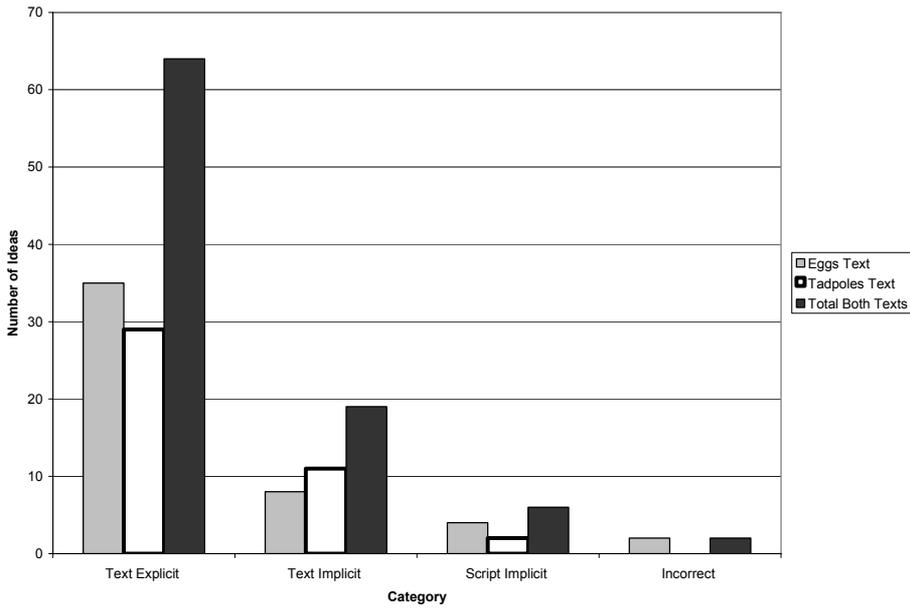
### What did children understand about the frog’s lifecycle?

To answer our first research question, we examined children’s responses to comprehension questions as well as the ideas in their observation logs, questions and predictions, and concept maps.

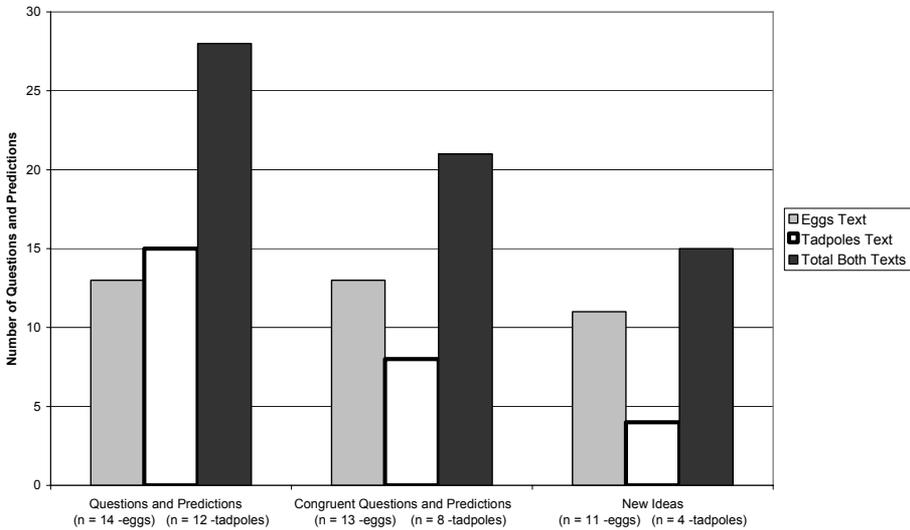
*Comprehension questions.* Children’s correct responses to the Do You Know questions in the texts and the review questions in the self-evaluation templates were summed to create a total score (out of 8) for comprehension. Results are presented in Table 1 and indicate the majority of children had a good understanding of the key concepts in the LLK, answering, on average, 7 out of 8 questions correctly.

*Observation logs.* To further examine children’s understandings about frogs’ lifecycles, we examined text explicit, text implicit, script implicit, and incorrect ideas in their observation logs. In each log, children were asked to describe how the eggs/tadpoles grow and change. Figure 1 shows the number and nature of ideas children generated about these topics. Children offered 64 text explicit ideas (35 from the eggs text, 29 from the tadpoles text), 19 text implicit ideas (8 from the eggs text, 11 from the tadpoles text), and 5 script implicit ideas (3 from the eggs text, 2 from the tadpoles text). Only 2 incorrect ideas (both from the eggs text) were conveyed in children’s explanations of growth and change.

*Questions and predictions.* We examined the number of congruent questions and predictions children generated from their study of each text. These findings are shown in Figure 4. In total, children generated 28 questions and predictions about eggs and tadpoles. Of those, 21 questions and predictions were judged to be congruent with the texts, and 15 of the congruent ideas asked for or made a prediction to extend information in the texts. Again, these findings indicate a generally high level of understanding about the content being studied. However, children generated more new ideas for the eggs text than for the tadpoles text.

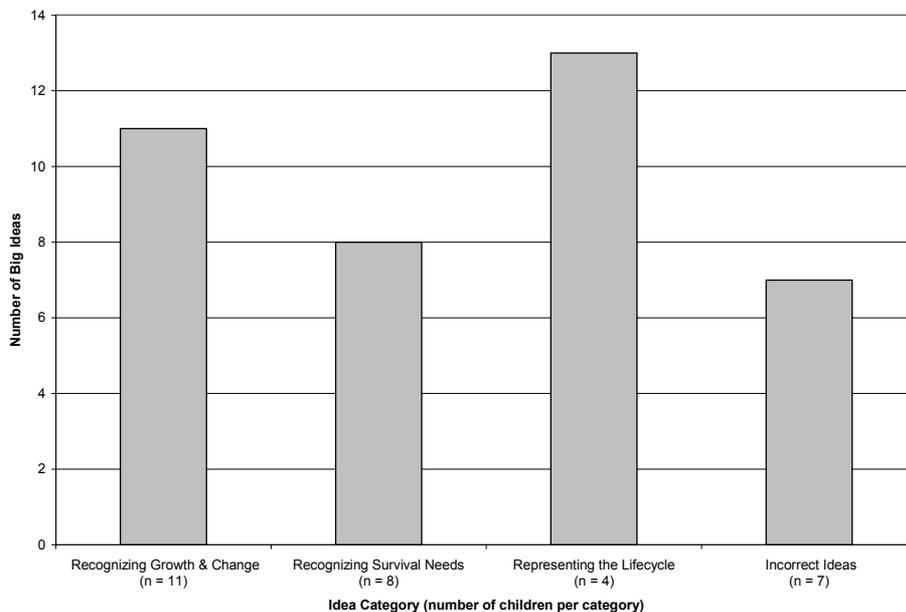


**Figure 3:**  
Ideas in children's observation logs.



**Figure 4:**  
Congruent and new ideas in children's questions and predictions.

*Concept maps.* Children’s concept maps and transcripts were analyzed for evidence that they attended to and understood the three main ideas about lifecycles and, more specifically, frogs’ lifecycles (i.e., Did children represent or mention growth and change, survival needs, and one or more phases in the frog’s lifecycle. Figure 5 indicates that the majority of children (61%) represented growth and change on their concept maps, and 44% of the children represented one or more of frogs’ survival needs. Only 4 children (22%) represented one or more phases in the frog’s lifecycle. However, on average, each of these children represented three of the four phases. These children described how frogs lay eggs (1), which hatch to become tadpoles (1), which grow and change into frogs (1), but did not repeat that the new generation of frogs also lays eggs to repeat the lifecycle. Finally, seven children (39%) represented information incorrectly on their concept maps, indicating some misconceptions about lifecycles and, especially, the lifecycles of frogs.



**Figure 5:**  
Ideas in children’s concept maps.

### How did children regulate learning as they studied the LLK?

Three sources of evidence were examined to address this research question. First, we examined gStudy’s log files to determine whether and to what extent children accessed the dictionary, More buttons, and Do You Know buttons while studying the texts, and whether they made use of opportunities to ask questions or make predictions after study-

ing the texts to extend their learning. The decisions, or choices, children make about whether and how to engage in these activities are indicative of metacognition (e.g., monitoring comprehension), motivation for learning (e.g., persisting to get the correct answer), and strategic action (e.g., accessing help). Second, we calibrated children's responses to comprehension questions with their judgments of knowing as a measure of their awareness of how well they understood the content in the two texts, and we calibrated what they said they did to study the LLK with what they actually did. Good calibration is likely to lead to SRL when it is warranted (Garavalia & Gredler, 2002; Winne & Jamieson, 2002). Finally, we examined children's spontaneous instances of SRL while they organized key concepts about the lifecycles of frogs on their concept maps. Our findings are discussed below.

*SRL while studying the LLK.* "SRL in LLK" was computed by summing children's interactions with the dictionary, Do You Know and More buttons, and prompts for questions and predictions across the two texts. In total, there were 11 opportunities for children to engage in these activities. Table 1 displays the descriptive statistics for this variable. On average children took advantage of about half of the opportunities to regulate their learning in the LLK ( $M = 6.44$ ,  $SD = 2.31$ ). The majority of children interacted with the Do You Know questions in the Eggs and Tadpoles texts, 83% ( $n = 15$ ) and 89% ( $n = 16$ ) respectively. Similarly, most children sought More information while reading the Eggs and Tadpoles texts, 72% ( $n = 13$ ) and 61% ( $n = 11$ ) respectively. Finally, most children took the opportunity to ask questions and make predictions from the Eggs and Tadpoles texts, 77% ( $n = 14$ ) and 67%, ( $n = 12$ ) respectively. However, only one child accessed the dictionary once across the Eggs and Tadpoles texts.

*Calibration.* Results indicate children demonstrated a reasonably high level of calibration while working in the LLK (descriptive statistics for the calibration variable are shown in Table 1). More specifically, 94% of children received a calibration score of 3 or 4 to reflect their judgments of knowing answers to the comprehensions questions. Similarly, the majority of children's self-reports of their SRL actions calibrated well with their actual actions in the LLK, which were recorded in the gStudy logfiles. These high levels of calibration indicate children were monitoring well, which is important because without effective monitoring children may not engage in other self-regulatory processes, such as reviewing and self-correcting. Alternatively, poor monitoring may lead learners to change correct responses to incorrect responses.

*SRL while concept mapping.* We examined children's unprompted SRL during the concept mapping activity by observing the changes children made to their concept maps (self-evaluation and self-correction), and recording their requests for support. In total, we observed 44 instances of self-evaluation and 26 requests for support. All instances of self-evaluation came from 13 of the children, and 59% of these considerations resulted in a more accurate representation of the main ideas in the LLK. Specifically, 10 children made changes to their concept maps that resulted in a more accurate representation and 8 children considered a change and then made a good decision to leave their representation the way it was. Only 2 children considered a change, but made a decision not to make a change that would have enhanced their representation.

The requests for support came from seven of the children. Most of these requests (65%) related to reading (e.g., “What is the word here?”). However, children also asked for help to find information (11%, “What is the word here?”), solve a technical problem (1 child, “I can’t get this to move.”), or consulted about groupings of key concepts (33%, “Is this right?”).

### What relationships exist among the variables of interest in this study?

We computed a series of Pearson product-moment correlations to examine relationships among the variables of interest in this study. In particular, we were interested in relationships between (a) teachers’ ratings of children’s achievement and motivation and children’s SRL and understanding of the frog’s lifecycle (i.e., their achievement on the LLK tasks), and (b) children’s motivation and SRL as they engaged with the LLK and their understanding of the frog’s lifecycle. Correlations with effect sizes are presented in Table 2. Considering our small sample size, effect sizes should be considered using Cohen’s (1992) criteria where (a)  $r = 0.1$  (small effect), (b)  $r = 0.3$  (medium effect), and (c)  $r = 0.5$  (large effect). There was a statistically significant and positive relationship between teacher’s ratings of children’s achievement and children’s performance on the comprehension tasks in the LLK ( $r = .47, p < .05$ ), corresponding to a medium to large effect size. In other words, teachers’ ratings of children’s achievement as high, average, or low were related to children’s understandings about the lifecycles of frogs in the LLK. Moreover, children’s self-reported motivation for the LLK was statistically significantly and positively related to their SRL while engaging with the texts and tasks in the LLK ( $r = .48, p < .05$ ), which was positively related to their performance on the LLK tasks ( $r = .74, p < .01$ ). These relationships correspond to moderate and very large effect sizes, respectively. They indicate children who took advantage of the opportunities the LLK presented to engage in SRL achieved higher levels of understanding about the lifecycles of frogs.

**Table 2:**  
Relationships among the Variables (N = 18)

Variable	1	2	3	4
Children’s motivation in gStudy	1	-	-	-
Teacher achievement ratings	-.02	1	-	-
SRL in gStudy	.48*	.20	1	-
Comprehension in gStudy	.27	.47*	.74**	1

Note. \* $p < .05$ , \*\* $p < .01$

## Summary discussion

Our data indicate most children participating in our study achieved a high level of understanding about concepts explicitly presented in the LLK texts. Most children generated questions and predictions that were congruent with the texts, although the majority of their questions and predictions did not require inquiry beyond the text. In terms of the major themes, just over 60% of the children referred to aspects of growth and change when representing the lifecycle of frogs in their concept maps, and approximately half referred to their survival needs. However, only 22% of the children represented two or more relationships among phases in the frog's lifecycle. These findings are consistent with those of other researchers who have studied young children's understandings of lifecycles (Samarapungavan et al., 2008; Nyberg, Anderson, & Leach, 2004). In particular, Nyberg et al. found children (aged 9-11 in their study) had difficulty linking one generation in a lifecycle to the next, especially when sexual reproduction was involved, and concluded children need extended opportunities for observation and discussion to understand these concepts. Children in our study received no direct instruction or prompting about these relationships. Ideally, the LLK would be implemented as part of a classroom unit on lifecycles and instruction and scaffolding could support young children's understanding of complex concepts associated with lifecycles.

gStudy traces indicated children were engaged in various forms of SRL, including checking and elaborating understanding during reading, asking questions and making predictions after reading, and evaluating learning at the end of each session and as they completed their concept maps. Moreover, children's SRL while studying the LLK was positively associated with their achievement on LLK tasks. These findings align with Samarapungavan et al.'s (2008) results and indicate young children can engage in fairly sophisticated forms of learning and inquiry. In their study, kindergarten children gathered and recorded empirical evidence to test hypotheses and extend and revise their knowledge of the butterfly's lifecycle. Children in their study asked scientific questions and made predictions that could then be addressed by the evidence in their investigations, and they were able to communicate about their investigations and knowledge. Samarapungavan et al. emphasize the role of classroom discourse and inquiry activities in facilitating children's understandings of lifecycles and scientific processes.

As is true of most studies, we recognize there are several limitations with our investigation, each of which suggests directions for future research. First, our sample size is small, which limits the generalizability of results. In-depth investigations of young children's SRL are labour intensive and large samples are not always practical within a single study. However, generalizability can be increased through replication, so our recommendation for future investigations is to replicate studies like this one in addition to trying to bring such investigations to scale. Second, we did not include a baseline measure of children's knowledge of lifecycles and, therefore, cannot make claims about what children learned, only what they understood. Future investigations should attend to this shortcoming. Finally, researchers offered only limited support for children's learning and SRL in an effort to study whether and how children would use opportunities and supports provided by the LLK. As a pilot of this software, this made sense. However, when the

LLK is embedded in a larger unit of study in children's classrooms, teachers and peers can provide extensive and instrumental support for learning complex scientific concepts and engaging in self-regulatory processes. Researchers should engage in experimental studies to understand how instruction and scaffolding influences children's learning and SRL in multimedia contexts and with tools like the LLK.

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