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Running Mates: Staying on Track for an Integrate Information Literacy and STEM Curriculum

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What treatment options are available for Alzheimer's? How are prime numbers involved in Internet security and encryption? Can computers keep getting faster? When will I have a robot butler? Will we ever cure cancer? Can we live forever? Where does the scientific information to answer these questions come from? How is it produced and disseminated? What makes one piece of information more useful than another? How do I find the scientific and technological information I need? How do I determine if this information is trustworthy? The essential skills and understandings necessary to both ask and answer these questions are the building blocks of both science and information literacy. In today's knowledge economy, with its emphasis on science, technology, engineering, and math (STEM) education and workforce development, it is essential that educators work to help students develop the science and information literacy understandings and abilities necessary to successfully navigate the emerging information landscape (National Academies of Sciences, Engineering, and Medicine, 2016; Swanson & Jagman, 2015, Priest, 2014).

Particularly in the current climate of information abundance and information overload, where accusations of "fake news" and the polarization and politicization of information sources abound, where for every fact there is an "alternative fact" a click away, and when prevailing wisdom seems to suggest that we live in a post-truth or post-fact world, science and information literacy competencies are more important than they have ever been before (Priest, 2013; Swanson & Jagman, 2015; Weinberger, 2014). This is compounded by the fact that scientific and technological research, data, information, and knowledge are being produced in exciting and innovative ways, making it increasingly more difficult for students to ascertain the validity and utility of information available to them (Badke, 2015; Priest, 2013; Weinberger, 2014). This challenge is particularly sensitive for STEM college students who are caught between faculty who expect them to understand and move comfortably within the traditional academic forms of information production, dissemination, and evaluation, and the new and emerging ways in which they act as creators, as well as consumers, of STEM information. In particular, educators need to equip STEM students with the science and information literacy competencies needed to participate in the processes of critical thinking and reasoned and informed discourse that is necessary to succeed in the classroom, in the workforce, and as lifelong learners who are meaningfully engaged with the creation, production, sharing, and discovery of information and knowledge in the digital age (ACRL, 2015; Asher, 2015; Bruce, 2004; Kellner & Share, 2007).

The Georgia Gwinnett College Library Information Literacy Omnibus

Information literacy has recently been redefined by the Association of College and Research Libraries' Framework for Information Literacy in Higher Education (Framework) as the "set of integrated abilities encompassing 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, 2015, p.2). To be information literate means that one has the ability to identify when information is needed, to locate and access information, to evaluate and think critically about information, and to effectively and ethically use information as both a consumer and a creator (AAC&U, n.d.).

In reading and thinking about the new conceptual understandings, knowledge practices, and dispositions that the Framework introduced, it became apparent that an overhaul of the existing information literacy program at the Georgia Gwinnett College (GGC) Daniel J. Kaufman Library was needed. To that end, the Research Services faculty librarians began to develop what would eventually become the GGC Library Information Literacy Omnibus. The Omnibus is a living document that aligns and scaffolds the many definitions, performance indicators, knowledge practices, dispositions, and milestones from the ACRL Standards for Information

Literacy, the ACRL Framework, and the AAC&U Information Literacy VALUE rubric to the GGC institutional and disciplinary student learning goals across the curriculum, by major, and within individual courses and classes.

The Omnibus serves as the foundation from which GCC Kaufman Library Research Services faculty librarians collaborate with various disciplines and curricular programs on campus to embed information literacy into and across the curriculum. One of our most successful partnerships is with the STEM faculty in the GGC School of Science and Technology, particularly the Information Technology and Chemistry disciplines. The Kaufman Library Research Services faculty and the STEM faculty have worked together for nine years to embed information literacy into three required general education courses, two introductory sequenced lecture and laboratory chemistry courses (CHEM 1211 & CHEM 1212) required for all STEM majors and an introductory information technology course (ITEC 1001) required for all GGC graduates. The Research Services librarians' work to adopt and adapt the Framework and the resultant creation of the Omnibus has revitalized these cooperative efforts and has led to major revisions of our collaborative information literacy initiatives. The library and disciplinary faculty worked together to identify and align our common student learning outcomes, to design and develop innovative instructional methods and technological tools, and to implement and evaluate a new series of STEM information literacy learning activities and assessments.

The resulting STEM information literacy initiative was developed using several interconnected theories and related practical models of instructional design. The process was influenced in part by Wiggins and McTighe's (2005) *Understanding by Design* and their model of backwards design. This model begins by identifying the enduring understandings and essential questions that frame the purpose of the intervention and in determining what students will know and be able to do as a result of participating in the intervention. The second step in this model is to decide what authentic assessments (performance tasks, written responses, self-assessments, etc.) will provide evidence of student learning. Finally, the learning plan that will guide students to mastery of the assessments and the content is developed.

The design of the initiative was also influenced by Dee Fink's (2013) *Creating Significant Learning Experiences*. The relevant parts of the design model for this intervention are establishing learning goals, designing authentic mechanisms for feedback and instruction, and developing teaching and learning activities. Both of these models were used in conjunction as part of the larger design process based on the ADDIE model of instructional design. The ADDIE model is a comprehensive and widely used model of instructional design that connects and extends the components of the backwards design and significant learning design. The ADDIE model consists of five phases: analysis, design, development, implementation, and evaluation (Davis, 2013). Figure 1 indicates the ways in which these three models of instructional design are aligned and integrated with one another.

Figure 1:
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The ADDIE model provided the foundation for the holistic design and development of the scaffolded STEM information literacy initiative. An examination of each phase and how it was applied to the development of the initiative follows.

Analyze Information Literacy Learning Goals & Outcomes for STEM Courses

In this phase the GGC Library and STEM faculty collaborated to determine the goals and desired outcomes of the science and information literacy learning experience (Davis, 2013). This process of analysis focused on determining what enduring understanding, essential questions, knowledge and skills comprised the learning goals of the related learning experience and on specifying the goals for the instruction and the student learning outcomes to be achieved (Gross, Latham, & Armstrong, 2012; Wiggins & McTighe, 2005). The enduring understandings, essential questions, and associated student learning outcomes were drawn from the Omnibus, the CHEM 1211, CHEM 1212, and ITEC 1001 course goals, and the GGC Integrated Educational Experience goals. An example of this alignment is shown in Table 1.

Table 1:
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Design of Instructional Plan for CHEM 1211, CHEM 1212, and ITEC 1001

In this phase "an outline of instructional strategies is created and learning activities and assessment are determined" (Davis, 2013, p. 205). This phase of the STEM information literacy initiative was designed using the ARCS model of motivational design. This model is a framework that can be used in conjunction with instructional design to increase both intrinsic and extrinsic motivation for learning and to improve information acquisition and retention (Hess, 2015). The ARCS model consists of four overlapping categories: attention, relevance, confidence, and satisfaction. Each of these categories is has a number of subcategories and related process questions as detailed in Figure 2.

Figure 2:
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These process questions and categories were used to enhance the design of the information literacy sessions. As Keller (1987) points out, the purpose of motivational design is to complement instructional design so that the content is engaging and interesting. This is especially important for motivating learning in the information literacy classroom, where students generally lack motivation for learning because they assume they already know the material to be covered, are overconfident in their searching abilities, and regard the content as essentially boring or irrelevant (Asher, 2015; Cole, Napier, & Marcum, 2015; Gross & Latham, 2012; Hess, 2015;).

Wiggins and McTighe (2005) and Fink (2013) recommend that after determining what you want students to learn, the next step should be determining how to assess learning. The Kaufman Library and STEM faculty determined that the information literacy components of these courses should have four parts: a pre-class assignment in which students conduct guided searches in order to answer specific questions, in-class activities that reinforce and expand on the understandings and skills introduced in the pre-class component, and both a post-test and a written reflection to gauge students' learning. Once the design plan for the teaching and learning activities and assessments was completed, the next phase was to develop the supporting course materials.

DEVELOPMENT OF SUPPORTING MATERIALS

The most essential item to develop in order to support student learning was a specific LibGuide for each course. Each LibGuide is tailored to the most relevant resources for students in that course, and so the guide itself becomes a source from which other course assignments can be created. Each guide contains categorical tabs for types of resources—articles, books, websites, and so on—and each tab contains information, links, multimedia materials, widgets, and suggestions to help students find appropriate material.

Once the course's LibGuide was in place, instruction librarians and course instructors worked together to create assignments based on the shared outcomes that were determined during the Analysis phase of the ADDIE process. For example, the initial assignment given to CHEM students took the form of a worksheet, which contained instructions to complete searches for many kinds of resources from the LibGuide. Through further iterations of ADDIE, the assignment evolved into digital formats: first, a quiz embedded into the students' course management system, which was easier to disseminate and collect than the original worksheet format. Then the assignment evolved further into an online guided quiz using Guide on the Side (http://code.library.arizona.edu/).

Guide on the Side has many advantages over the previous iterations of the assignment, and it continues to be the preferred format for both Library and STEM faculty. This teaching tool provides a link that students click on to open a browser window that contains assignment information and questions arranged adjacent to a live instance of the Library's website. As students click through the prompts in the Guide on the Side window, they also carry out the requested searches and navigation on the live website in the adjacent window. This design allows Guide on the Side assignments to be easily and quickly edited, without any changes made to access instructions.

IMPLEMENTATION & EVALUATION OF THE STEM INFORMATION LITERACY INITIATIVE

The redesigned initiatives for information literacy in CHEM 1211 and ITEC 1001 were piloted in the Fall 2016 and the Spring 2017 semesters in two sections of ITEC 1001 and in all 56 sections of CHEM 1211. Following Fink's (2013) model for creating significant learning opportunities, the STEM information literacy initiative is being evaluated by asking the following questions:

- Did the information literacy instruction provide foundational knowledge?
- Did the information literacy instruction provide opportunities for practical application?
- Did the information literacy instruction encourage students to integrate learning with other academic and personal experiences?
- Did the information literacy instruction encourage students to find value in becoming more Google literate?
- Did the information literacy instruction help students learn more about how they learn and encourage other metacognitive habits?

These questions will be answered using data from the pre-class assignment, the post-class assessment, and the written reflections. As the pilot program has recently drawn to a close, evaluation is in the early stages. Library and STEM faculty will continue working together to analyze the data and apply their findings to the next iteration of the STEM information literacy initiative.

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FIGURE 1 - INTEGRATED INSTRUCTIONAL DESIGN MODELS

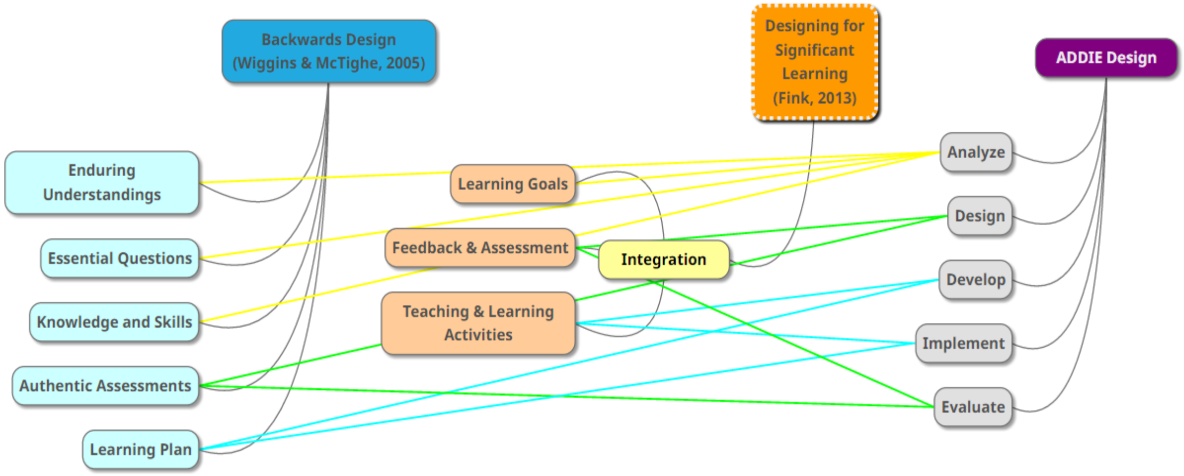

TABLE 1 - ITEC 1001 INFORMATION LITERACY STUDENT LEARNING OUTCOMES

ITEC 1001 Course Goals	ITEC Program Goals	GGC IEE Goals	IL SLO
2. Describe the ethical issues surrounding the uses of digital information.	4, 9	2, 3, 6	1. Critically evaluates contributions made by others in participatory information environments to determine reliability, accuracy, validity, authority, timeliness, and point of view or bias of information found.
5. Acquire basic knowledge of computer security, protection mechanisms and privacy threats on Internet.	4, 6, 8, 9		2. Understands how the commodification of their personal information and online interactions affects the information they receive and the information that is produced or disseminate online, including information they create.
			3. Makes informed choices regarding their online actions in full awareness of issues related to privacy and the commodification of personal information.

TABLE 2 - CHEM 1211 & 1212 INFORMATION LITERACY STUDENT LEARNING OUTCOMES

GGC IEE Goals	CHEM 1211K & 1212K Goals	IL SLO 1211K	IL SLO 1212K
1,2,4	7. Apply constructed lecture and laboratory knowledge to an on-giong campus-wide experimental research project	1. Match information needs and search strategies to appropriate search tools;	1. Recognize that the scholarly journal literature and other specialized resources can be accessed via library collections (print and electronic), often via institutional log-in
		2. Design and refine needs and search strategies as necessary, based on search results; and	2. Describe and define open databases and datasets, subscribed databases, and meta-databases and discuss the differences, benefits, and limitations of each.
		3. Understand how information systems are organized in order to access relevant information	3. Realize that information sources vary greatly in content and format and have varying relevance and value, depending on the needs and nature of the search (F.SE.d.3)
		4. Identify a variety of types and formats of information products as potential sources for information	4. Define and discuss the different creation processes that result in specific types of information products

FIGURE 2 - ARCS MODEL OF MOTIVATIONAL DESIGN