PROGRAM REQUIREMENTS FOR THE MISE PH.D. PROGRAM

This document summarizes what is required for successful student completion of the MISE Ph.D. Program in terms of both student and faculty responsibilities. Exceptions to any policy item can only be granted by a majority vote of the MISE faculty. As with all requirements, the faculty will discuss any exceptions or problems as a group and come to a unified consensus that is in the best interest of the student. Topics are presented in the following order:

1. Program Elements
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3. Research Committee Formation
4. SCI 6170-6171 Early Research Experience I & II
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1. Program Elements
   The following describe the required components of the MISE Ph.D. Program
   A. *Core Coursework Grade Requirement:* The student must pass SCI 6140, 6150, and 6160 with an average GPA of 3.5 or better; each course can be taken one additional time to improve GPA, if needed. The highest grade received for each course will be used in the GPA calculation.

A	=	4.0
BA	=	3.5
B	=	3.0
CB	=	2.5
C	=	2.0

   B. *SCI 6170-6171 Early Research Experience I & II:* The student must pass this two-course series that provides experience in critical evaluation of the research literature and experience in conducting mentored research. In SCI 6170, students develop a Memorandum of Understanding with their faculty mentor that describes the faculty and student responsibilities for the research to be carried out. The SCI 6170 course culminates in a Research Proposal which is then carried out under the faculty mentor's supervision in SCI 6171.

C. *Early Research Requirement (ERR):* An original research study is designed and carried out by the student with faculty mentorship. Our program is designed such that the SCI 6170-6171 course sequence leads to the ERR. However, students may fulfill the ERR with a different project. The ERR has four requirements:
- Present the completed study in a MISE symposium,
- Present the completed study externally at a professional conference ,
- Prepare a manuscript describing the completed study that is reviewed and approved by MISE faculty (can be re-submitted one time with revisions if needed), and
- Submit the completed manuscript to a peer-reviewed journal for publication review.

D. *Comprehensive and Critical Literature Review (CCLR)*: Upon successful completion of the core coursework and the ERR, the student prepares a comprehensive and critical literature review in an area pertaining to the student's intended dissertation research. The CCLR is supervised by a 3-member committee. The CCLR has two requirements:
- Present the approved CCLR at a MISE symposium, and
- Approval of the final written document by the CCLR committee.

E. *Dissertation Proposal*: Upon successful completion of the CCLR, the student's dissertation committee is officially formed and the student develops a dissertation research proposal. The proposal has two requirements:
- Present the approved dissertation research proposal at a MISE symposium, and
- Approval of the final written proposal by the committee.

F. *Dissertation Defense:* Upon successful completion of the dissertation proposal, the student works on his/her dissertation research. The finished dissertation has three requirements:
- Defend the approved dissertation at a MISE symposium,
- Approval of the final written dissertation by the committee, and
- Submission of the approved dissertation to the Graduate College.

2. Definition of Advancement to Candidacy

Candidacy is defined as having completed program requirements (A) through (E), above. A student is permitted to enroll in dissertation credits (SCI 7300) after these are completed.

3. Research Committee Formation

A faculty research committee that will guide a student's research can be formed at any time, but no later than the time that the CCLR is started. A research committee could be formed early such that this committee works with the student through the ERR, CCLR and dissertation processes. Or, formation of this committee could be delayed until the start of the student's CCLR. Committee membership may change through ERR, CCLR, and dissertation process.

Committees are formed through consultations involving the student, the MISE Director, and interested faculty. Committees must be chaired by a MISE faculty member. Although students and faculty have input into committee membership and who will serve as Committee Chair, the MISE Director will make final decisions regarding committee composition. Both CCLR and Dissertation committees must include a second MISE faculty member (in addition to the Chair) and at least one additional member from outside MISE. CCLR committees are limited to 3 members. Dissertation committees can have additional members. Documentation on committee formation, changes to committee membership, and faculty agreement to serve, are placed in the student's file. Committees are not official until all appropriate documentation has been approved and filed at the MISE office.

4. SCI 6170-6171 Early Research Experience I & II

This two-course series is designed to give science education doctoral students direct experience in the process of designing and conducting original research in science education. Note that research in science education may be of various types, e.g. empirical, conceptual, theoretical, historical or philosophical, or a combination, and may thus use a variety of methods.

In the first course (SCI 6170) students conceptualize and design their own research projects, gather and critically appraise the relevant literature, and write a formal Research Proposal. In the second course (SCI 6171) the student carries out this research under the guidance of a faculty mentor, and writes a Research Report. These two courses and their rationale and requirements are described in more detail below. Specific assignment information and grading criteria are available in the SCI 6170 and 6171 syllabi.

A. **SCI 6170 Early Research Experience I.** In SCI 6170, each student conceptualizes and designs a suitable research project, in consultation with the course instructor and a faculty mentor under whose guidance the research will be conducted. Each student's developing research ideas and progress is presented and discussed by the group as part of the weekly class sessions, providing ongoing feedback for change and improvement. At the same time students will be seeking relevant literature and compiling and critically appraising work pertinent to the project. In weekly classes, students report both on their progress in designing the project and on valuable ideas from literature pertinent to their research. Some of this literature may become part of assigned readings for class discussion where appropriate.

- *Memorandum of Understanding.* During 6170 a Memorandum of Understanding (MOU) will be drawn up and signed jointly by the student, the 6170 instructor, and the mentor (and committee members if a committee has already been formed at this stage). This memorandum may be regarded as an agreed 'contract', and outlines in some detail the nature and extent of the work that will be undertaken on the particular research project by the student during 6170 and 6171, with a reasonable timeline for each stage. It also specifies the student and mentor responsibilities on the project and what is required of both. The 6170 instructor and the mentor should consider a MOU carefully to ensure it involves a viable project and a reasonable amount of work for a student during the 6171 semester. It is understood that research projects differ, may involve different amounts of work and time, and that not all students will begin or end at the same place. Thus MOUs must be worked out to ensure that all students will be doing appropriate and equitable amounts of work on their projects. If a student's research proposal or MOU seems over- or under-ambitious, the 6170 instructor, student and mentor should meet to further discuss reasonable expectations.
- *Research Proposal.* The eventual outcome of the research development and literature aspects together is each student's production of a formal Research Proposal for their chosen project during 6170. This proposal should outline the entire research project, as it is intended to be fully enacted. It should describe and motivate the proposed project, its context, purpose, conceptual framework, theory base, research goals, stages, methods, data sources, proposed analyses, etc., and should include a corresponding focused literature review for the area of interest. The proposal document should be written along the lines of formal proposals submitted for research grants, and the faculty instructor and mentor can advise in this regard. Besides a comprehensive account of the proposed research the document should also include a timeline and estimated budget.

Note that SCI 6170 is a class with grades assigned by the 6170 instructor of record for work done, assignments, contributions, and progress achieved during the course. As such, the learning objectives of the assignments, including the MOU and Research Proposal, are tied to the overall course goals. The Research Proposal may be used as the starting point for the CCLR and/or dissertation proposal (see below), however students should expect substantial refinement and revision as the scope of dissertation research will be more significant than the 6170-6171 project.

B. **SCI 6171 Early Research Experience II.** In SCI 6171, the second course in the sequence, students will carry out their proposed research, under the guidance of their faculty mentor, and in accordance with the MOU. Students will keep a full Research Record of all stages of the project as carried out, including work done, ideas, modifications, improvements, literature, data, analyses, interpretations, conclusions, etc., even dead-ends and lessons learned. This work will culminate in a formal Research Report for 6171. Students will continue to meet weekly as a group with the former 6170 instructor, however, all work should be submitted to the 6171 faculty mentor and the grade will be assigned by the faculty mentor.

Given the nature of research, the project may extend beyond the 6171 semester, in which case this will be agreed by student and research mentor and the MOU updated accordingly. If all stages of the research are not complete by the end of the semester, the 6171 Research Report should give a full account of the work and stages achieved so far, with plans for completion.

The SCI 6170-6171 course sequence is typically used by a student to fulfill the MISE Early Research Requirement (ERR, see 5 below). Students who enter having largely completed their ERR requirement in another way should use the courses to start developing their CCLR document (section 6) and/or dissertation proposal (section 7), and the MOU and Research Proposal should be written to reflect this. Having fulfilled the Early Research Requirement with a different research project does not exempt the student from any requirements in the SCI 6170-6171 course sequence.

5. Early Research Requirement (ERR)

The goal of the ERR is for (i) students to experience the full research process, and (ii) to demonstrate competence with specific aspects of the research process. All parts of this process are to be carried out under the guidance of a faculty mentor or research committee.

Under (i), students are expected to lead a research project from conceptualization to publication, including specifically:

- Design a study (e.g., identify research goals or questions, review appropriate literature, identify a theoretical framework, choose methods, obtain HSIRB approval, etc.)
- Conduct the study (e.g., collect, analyze, and interpret data)
- Communicate the research in a presentation external to MISE
- Communicate the research in a manuscript submitted to a peer-review journal

The purpose of (ii) is for students to demonstrate sufficient mastery of research skills to continue in the doctoral program, and for students to obtain formative feedback to improve their external presentations and publications. Students are expected to demonstrate the following aspects of research competence as evaluated via the associated rubrics and additional feedback:

- Communicate the process and results of the research project in an internal MISE presentation
- Communicate the research in a manuscript suitable for peer-review, submitted to the MISE faculty

Our program is designed for students to begin their early research as part of the SCI 6170-6171 course sequence (see section 4, above). However, it is also possible for students to complete these requirements with a project undertaken outside of SCI 6170-6171 (for example, grant-related research).

Regardless of the source of the research, these requirements can only be met with a project *for which the student has substantial intellectual ownership*. In other words, a project in which the work has been completed by a faculty member and a student name has simply been added to it, is not acceptable. Likewise, work on a grant that was written and conceptualized by a faculty member in which the student is simply doing research already thought through by the faculty member is not acceptable. A grant project undertaken by a faculty member can, of course, represent an opportunity for a student to do his or her ERR project—the point is that the student's ERR project must be in some sense distinct from the original grant, i.e., involve the development of research questions that are distinct from those originally proposed in the grant and include a critical appraisal by the student of additional literature.

By the completion of the ERR project, all students must get to the point where they have analyzed a set of data and drawn conclusions from that analysis. Once they have reached this point they will be able to complete the following four requirements (not necessarily in this order):

A. **MISE Presentation**. Students should schedule a 40-45 minute block (20 minute presentation and 20 minutes of discussion/feedback) to present their ERR project to the MISE community. This presentation is meant as an opportunity for students to present their work in a safe and constructive environment before presenting at a state or national conference. The presentation allows faculty and other student to learn about the presenting student's research interests, and to provide critical and constructive feedback that improves the work. Feedback will be provided orally and via rubric (see Appendix I). Students should submit a 3-5 page executive summary of their research and schedule the presentation with the MISE office *with the permission of their mentor* at least 14 days prior to the presentation date.

B. **Research Conference Presentation**. Students will present their work at a research conference (see Appendix II for recommended conferences) at the state, national or international level. The faculty prefer that the conference be competitive, such that students would need to submit a presentation proposal to the organization, have it reviewed and selected on merit. The conference and presentation must be research-oriented. Both oral and poster presentations are acceptable to fulfill this requirement. Students should copy their acceptance notification and relevant conference program page to include in the yearly SPAR.

It is possible that a student may have done research prior to their early research requirement and that they would have already presented either orally or through a poster at a qualifying event. These presentations may count for the early research requirement, but it must be clear that the student was the sole or primary author of the talk or poster. The student and faculty mentor must request post-hoc approval from the MISE faculty. MISE faculty will consider each request individually. Presentations in which students' names were added, but for which most of the work was conducted by a faculty member or another student do not qualify.

C. **MISE Paper Submission**. The student must formally write up a publishable manuscript and submit it to the MISE faculty for review. The student will submit this paper and a cover letter to the *current* 6170 instructor, who will serving as MISE Editor, then disseminates it to a committee of at least two MISE faculty (not the student's research mentor or mentors). These faculty will act as reviewers of the work and submit an evaluation of either "Pass" or "Revise and Resubmit" plus recommendations for changes or improvements. Faculty may choose whether or not to remain anonymous during the review process. The MISE Editor will summarize the reviews and forward the decision and recommendations to the student. (More detailed directions guiding the submission of manuscripts are provided in Appendix III. The rubric faculty will use to evaluate manuscripts is provided in Appendix IV.) In the event that the student's faculty mentor happens to be the MISE editor, a different faculty member (usually the previous editor) will be assigned the role of editor for that student.

If the student is required to revise and resubmit, the student and mentor may request a meeting with the MISE editor and reviewers. Such a meeting would be for formative purposes so that the student better understands what revisions are needed and why. The meeting would also give the student the opportunity to clarify possible misunderstandings about the paper. The resubmitted paper should be accompanied by a cover letter that point-by-point addresses each of the MISE editor and reviewer concerns. Students are encouraged to work closely with their mentor during this review process, and must obtain his/her approval prior to the resubmission. The resubmitted paper may be sent to the same faculty reviewers, or may be sent to one or more new reviewers who will be asked to check that all of the prior concerns have been addressed.

Failure to submit a suitably revised paper or a paper that receives a recommendation of "Not Pass" on the second attempt may result in the student's dismissal from the doctoral program. A "Not Pass" will trigger a MISE faculty review of the student's entire record in MISE. Based on this review and on the findings of the ERR review process, the MISE faculty will determine whether the student will be allowed to continue in the doctoral program and on what conditions, or dismissed.

D. **Journal Submission.** The student is required to submit his/her manuscript to a peer-reviewed journal (see Appendix V for recommended journals) after submitting the manuscript for review by the MISE faculty. Ideally this will take place after the student has received comments from the MISE reviewers. This, therefore, requires that the students seriously discuss with their ERR advisor the type of journal that would fit best with their research and would be most likely to publish it. The student should maintain a copy of the submission confirmation provided by the journal, and include the confirmation in the yearly SPAR, along with a copy of the submitted manuscript. It is not necessary for the manuscript to be accepted for completion of this ER requirement. Students are encouraged to continue pursuing publication, considering reviewers' comments.

6. Comprehensive Critical Literature Review (CCLR)

The purpose of the CCLR is for the student to identify and critically evaluate the domains of knowledge relevant to the dissertation project. The CCLR is not a proposal designed to answer a specific research question, but should be guided by the student's intended dissertation research focus. There are four objectives within the CCLR in that students will: (1) develop expertise in relevant literature as expressed by the ability to document the breadth of the field, (2) identify and evaluate important papers in the field, (3) synthesize and identify specific needs within the relevant domains of knowledge, and (4) identify significant research questions arising from the analysis of the literature. In short, the CCLR should address the question "what does the literature say about the state of knowledge in this research field (or fields), and are these legitimate claims?"

Students can begin working on the CCLR at any time; however, the CCLR cannot be presented at MISE until the professional core courses have been completed with an average GPA no less than 3.5, four research tools courses completed, and all ERR components completed (some flexibility regarding the conference presentation of the ERR will be allowed). The CCLR may build from the student's prior work in the SCI 6170-6171 course sequence and/or on the ERR project, or may be an entirely different project. In either case, it must be directly related to the intended dissertation research.

To begin work on a CCLR requires that the student have an officially approved research committee in place. This committee of three will include a major advisor along with a second MISE faculty member and an outside member (see section 3, above). Students will work closely with their committee to set the format of the CCLR, including what general topics should be covered and how they should be arranged. It is expected that the student will work most closely with his or her major advisor, however,

the full committee should stay informed of the general progress of the CCLR and provide input on the conceptualization, format, design, and literature selection. It will be the responsibility of the committee as a whole to work together in an effective manner to ensure that the student understands their responsibilities in writing the CCLR.

The CCLR consists of two products: a written document and a public presentation.

A. **The CCLR Document**. The guidelines for this document are purposefully broad. The student should demonstrate by the end of the document that they are able to meet the four objectives stated above:

- The term "comprehensive" in the CCLR addresses objective (1). Within the CCLR, the student should document the breadth of literature, both historical and current, within specific research fields that are pertinent to the intended dissertation research project. Note that a clear and coherent rationale for the identification of the relevant research fields, as well as for the inclusion and exclusion of specific literature, is to be provided.
- The term "critical" in the CCLR addresses objective (2). A selection of important ("critical") papers from the relevant literature fields should be critically analyzed. These should include seminal works in the research field, as well as papers that are immediately relevant to the student's intended dissertation topic. Note that "critical" does not merely mean that the student should find fault with these papers - strengths, weaknesses, and contributions of this research should be examined.
- The term "critical" also related to objective (3). To address this objective, the student should effectively integrate the literature that she or he has reviewed, identify the major findings associated with the research fields explored, and evaluate the status of work within these fields. This synthesis should lead to the identification of demonstrable needs in the field, which may be an absence of literature, flawed or incomplete methods used, inconsistent or weak claims within the field, or even incomplete or inconsistent theoretical frameworks within the field. All of these issues should be considered as the student evaluates the status of knowledge within the identified research fields.
- This synthesis of the state of knowledge in the relevant research domains lead to objective (4). Here the student should recommend potential future directions of research and identify significant potential research questions that arise from the analysis of literature. One or more of these research questions should be directly related to the intended dissertation project.

It is important to note that not all faculty will ask students to format their CCLR in exactly the same way. Students should understand that these differences reflect differences in the science education community as a whole. The faculty are committed to working together and respecting differences in approach, while upholding the high standards they have set for students.

There is a rubric to consider when preparing the CCLR (see Appendix VI). It outlines the expectations the faculty have of the students. The rubric is meant for formative purposes only and will NOT be used to score a student's CCLR, because of the difficulty in setting a fair quantitative measure of passing. Furthermore, the rubric categories should not be thought of as headings or chapters for the CCLR. If students are unsure of what any of the categories or criterion mean, they should consult their major advisor for clarification.

The final CCLR document should be submitted to the student's committee for review. The student will continue to work on the CCLR until the committee is satisfied with the written document. If a student feels that his or her progress on the CCLR is being hindered by the committee, he or she may appeal to the MISE Director.

B. **The CCLR Presentation**. Once the student's committee has approved the written document, the student my schedule his/her CCLR presentation. A 1.5 hour block should be scheduled to accommodate the 40 minute presentation and 45-50 minutes of faculty and student questions. Students should submit a 5-8 page (not including references) executive summary of their CCLR to their committee chair at least two weeks prior to the presentation date, and schedule the presentation with the MISE office at least 14 days prior to the presentation date.

     The presentation should demonstrate the student's ability to both critically review and synthesize the literature contained within the CCLR. The presentation has multiple purposes: (a) for students to gain practice in scholarly presentations, (b) for faculty and other students to become informed about student work, and (c) for faculty and students to provide critical feedback intended to shape and improve the project. It will not be possible for the student to present the full scope of the CCLR document in the time allotted, therefore, the student should work closely with his/her committee to determine the best structure for the presentation and the most appropriate literature to highlight.

     At the conclusion of the CCLR presentation, the MISE faculty will remain in a closed session with the CCLR committee members (excluding the student presenting). Faculty at this point may share any concerns about the student's presentation and intended work. This faculty feedback may necessitate additional revision to the CCLR document. However, the final decision as to when a student's work passes the CCLR is at the discretion of the committee.

7. Dissertation Proposal

     Once the CCLR is passed, the Graduate College document on dissertation committee formation is to be filed. It is expected that the student and committee chair will keep in regular communication with the full committee about student progress. If a student feels that his or her progress on the dissertation proposal is being hindered by the committee, he or she may appeal to the MISE Director.

     The dissertation proposal is a research proposal and should at minimum contain the following elements: abstract, context and problem statement, theoretical framework, research goals and/or questions, literature review, and methods. The exact structure of the document is at the discretion of the committee. It is possible for the student to draw from their prior 6170-6171 coursework, ERR, and the CCLR for the dissertation proposal. The CCLR, however, may need modification to fit the research goals and/or questions; thus additional literature may need to be included or tangential research eliminated to align this document with the research objectives. Second, the dissertation proposal will describe a research project that is more substantial than in the 6170 proposal (and the ERR), as well as one that is originally designed by the student, rather than designed co-constructively with faculty.

     The written dissertation proposal should be submitted to the student's committee for review. The student will continue to work on the proposal until the committee is satisfied with the written document. Once the student's committee has approved the written proposal, the student may schedule his/her proposal defense. A 1.5 hour block should be scheduled to accommodate the 40 minute presentation and 45-50 minutes of faculty and student questions. Students should submit a 5-8 page (not including references) executive summary of their dissertation proposal to their committee chair, and schedule the presentation with the MISE office at least 14 days prior to the presentation date.

     As with the CCLR, the dissertation defense serves to both inform MISE faculty and other students about a student's research, and provides an opportunity for critical feedback that can improve the intended project. At the conclusion of the defense presentation, the MISE faculty will remain in a closed session with the dissertation committee members (excluding the student presenting). Faculty at this point may share any concerns about the student's presentation and intended work. At this point, students may be asked to revise or re-conceptualize the written document to take into account any questions or concerns raised in the oral defense. Faculty input will be considered, but the final decision

as to accepting the dissertation proposal is at the discretion of the committee. Once the final proposal has been approved by the committee, the student is able to complete the dissertation research and move onto their dissertation defense.

8. Dissertation Defense

The final dissertation describes the full extent of the student's research and is expected to include the following elements: abstract, context and problem statement, theoretical framework, research goals and/or questions, literature review, methods, results, discussion, limitations of the study, implications for future work, and conclusions. The exact organization of the dissertation is at the discretion of the student's committee. The student is encouraged to make use of the dissertation proposal in writing some of the final dissertation, however, it is quite likely that revisions will be required as the research takes shape and conclusions emerge.

It is the shared responsibility of the student and the committee chair to keep all committee members informed of research progress as the student works on his/her dissertation. This regular communication will ensure that the committee has a shared vision of the project and can give the student consistent and timely feedback. Students should expect there to be multiple revisions to the written document until the committee is fully satisfied.

Once the student's committee has approved the written document, the student may schedule his/her dissertation defense. A 1.5 hour block should be scheduled to accommodate the 40 minute presentation and 45-50 minutes of faculty and student questions. Students should submit an 8-10 page (not including references) executive summary of their dissertation to their committee chair, and schedule the presentation with the MISE office at least 2 weeks prior to the presentation date.

The presentation is an oral defense of the dissertation research. As with the CCLR and the dissertation proposal, it serves to inform other faculty and students about the student's research and as a final opportunity to gather feedback that can refine the work. As such, a student may be asked to make revisions to the written document based on feedback received at the defense. Faculty input may be solicited, but the final decision to approve the dissertation lies solely with the committee. Once the written dissertation is approved by the committee, it may be submitted to the Graduate College.

To be clear the goals and mode of evaluation for each of the major requirements are outlined in Section 9 (Table). If students have any questions, they are encouraged to first look at the supplemental documents provided in the handout and then speak with their advisor. If faculty have any questions, they should raise these at a faculty meeting or via email, so that students receive consistent and accurate messages from all faculty.

9. Table Summarizing Major Requirements of the MISE Ph.D. Program

Major Requirement	Sub-Requirement(s)	Goal(s)	Evaluation
Core Coursework	SCI 6140 SCI 6150 SCI 6160	• Provide students with foundational knowledge of science education • Evaluate student readiness to complete the PhD program	Grade given in each course by course instructor. Students must have BA (3.5) or higher grade point average across all courses.
SCI 6170	MOU	• Provide students with an appropriate guide for reasonable research goals • Set a contract to outline responsibilities of both students and faculty in completing the stated research goals	Grade given by SCI 6170 Instructor (First Semester)
	Research Proposal	• Provide students the opportunity to develop their ERR project* • Provide students practice in writing a research grant proposal	Grade given by SCI 6170 Instructor (First Semester)
SCI 6171	Early Research	• Carry out research project in alignment with the MOU	Grade given by SCI 6171 Instructor (Second Semester)
Early Research Requirement (ERR)	MISE Presentation	• Give students formative feedback on their ERR project before presenting at a conference.	N/A (Presentation counts as Pass)
	Outside Presentation	• Give students experience presenting at a professional conference	N/A (Presentation counts as Pass)
	MISE Paper	• Provide students with formative feedback intended to improve their work • Ensure students have appropriately written up their ERR before submitting to a peer-reviewed journal	"Pass" or "Revise & Resubmit" awarded by committee made up of the MISE editor (current SCI 6170 instructor) and two MISE faculty reviewers. Second "No Pass" triggers faculty review of student's record and possible dismissal from the program.

	Journal Submission	• Give students experience submitting to peer-reviewed journals • Give students an opportunity to get a publication	N/A (Submission counts as Pass)
Comprehensive Critical Literature Review (CCLR)	Written document	• Students learn to focus their dissertation research ideas to formulate sound projects • Demonstrates student's ability to effectively integrate and critically analyze literature into one document	Continual revision until approved by 3-member CCLR committee.
	Oral presentation	• Demonstrates student's ability to orally present the synthesized and analyzed literature • Provides opportunity for feedback to improve the student's work	Faculty feedback after presentation may be considered in committee review of the written document
Dissertation Proposal	Written proposal	• Write a proposal for the dissertation research • Demonstrates student's capacity to independently design a research study	Continual revision until approved by dissertation committee, of at least 3 members.
	Oral defense	• Defend proposed research study to faculty and students • Provides opportunity for feedback to improve the research	Faculty feedback after presentation considered in committee's review of the written proposal
Dissertation Defense	Written dissertation	• Present the research in a written format • Demonstrates student's capacity to design and carry out independent research	Continual revision until approved by dissertation committee, of at least 3 members.
	Oral defense	• Defend completed research study to faculty and students	Committee feedback after presentation may be incorporated into final written dissertation

*Students who have already completed their ERR may use SCI 6170 to begin preparation of their CCLR and dissertation proposal.

10. Appendix I. Feedback for MISE ERR Presentations

Aspect for Evaluation With suggested questions to guide evaluation	Rating	Comments
Substance		
1. Nature and significance of the project Is the essence / purpose of the project clearly described? Is the problem that the study addresses clearly outlined? Is the originality, importance and significance of the study clearly established?	Excellent Good Fair Poor Not Applicable	
2. Relevant Literature Is the study adequately grounded in literature relevant to the project? Is the literature cited clearly and critically appraised?	Excellent Good Fair Poor Not Applicable	
3. Research Goals/Questions Are the research goals / questions of the study clear and appropriate? Are the goals and questions well motivated with reference to the cited literature?	Excellent Good Fair Poor Not Applicable	
4. Research Design and Methodology Is the design of the study appropriate to tackle the research goals / questions? Are the methods, procedures, research design and instruments suitable and aligned with the goals?	Excellent Good Fair Poor Not Applicable	
5. Research procedures, Data Collection and Analysis Has the research been conducted appropriately? Was data collection careful and adequate? Are the data-analysis methods explicit, suitable and well motivated? Are all concepts, constructs and methods involved clearly explained?	Excellent Good Fair Poor Not Applicable	
6. Results, Interpretation, and Discussion of Findings Are the data analyzed correctly and interpreted appropriately? Are the research results clear and well presented? Are findings and insights well argued and discussed? Are suitable examples and/or data extracts provided? Are the conclusions and/or implications appropriate and related to the research goals? Are implications for instruction, limitations, and future work discussed?	Excellent Good Fair Poor Not Applicable	
Style		
7. Organization Is the overall organization of the presentation logical and coherent? Is the structure and flow of the talk easy to follow? Is the talk given at an appropriate level for the topic and intended audience?	Excellent Good Fair Poor Not Applicable	
8. Visuals Are the font sizes adequate for audience viewing? Does the presentation make good use of color schemes? Are the graphics uncluttered and clearly labeled? Are the visuals free of typos and grammatical errors?	Excellent Good Fair Poor Not Applicable	
9. Speaking Does the presenter speak clearly? Does the presenter speak at an appropriate volume for the room? Does the speaker avoid verbal tics ("um," "like," etc.)? Is the pace of the presentation appropriate?	Excellent Good Fair Poor Not Applicable	

11. Appendix II: Recommended ERR External Research Conferences

American Association for the Advancement of Science National Meetings (AAAS)
American Association of Physics Teachers National Meetings (AAPT)
American Education Research Association National Meetings (AERA)
American Geophysical Union (AGU) National or Regional Meetings
Association for Science Teacher Education National Conferences (ASTE)
Association of American Geographers (AAG) East or West Lakes Division Conferences
Association of American Geographers (AAG) National or Regional Conferences
Biennial Conference on Chemical Education (BCCE)
Earth Educators Rendezvous (EER)
Geographic Education National Conferences
Geological Society of America (GSA) National or Section Meetings
Gordon Research Conference: Chemical Education Research and Practice
International Geoscience Education Organization (IGEO) Conference
International History, Philosophy and Science Teaching Group Meetings (IHPST)
Michigan Academy of Science, Arts and Letters
National Association for Research in Science Teaching National Meetings (NARST)
Physics Education Research Conferences

This list is not exhaustive.

12. Appendix III. Directions for the Submission of ERR manuscripts for Review by MISE Faculty

Submitting your Early Research Paper for MISE faculty review:
When submitting your early research requirement (ERR) paper for internal review, please provide a cover letter (email or document attachment) that includes the following:

1. A few sentence overview of the purpose of the study and study design (e.g., purpose, research design, and main findings).

2. The name of the journal that you are submitting to. If there are any specific journal or review requirements that you'd like the faculty to know about, feel free to include these. Also keep in mind that the faculty members reviewing your paper may not be specialists in your research area, so feel free to also include any specialized terminology that might help with the review.

3. The name of your mentor and any other coauthors. Use the cover letter to draw attention to your role on the project, in particular, your role in conceptualizing the research, performing a critical review, analyzing and interpreting the data you collected, and writing up the study. Please distinguish between your contributions and those of your mentor and/or coauthors. You should also indicate the role of anyone who assisted with you on your project, particularly MISE faculty members. If your project was part of a larger study, please indicate how your project relates to the goals and purpose of the larger study.

Be sure to include the name of your mentor and any other coauthors in your cover letter only. (The manuscript should only have your name.) MISE faculty members who assisted you on your project cannot serve as reviewers of your paper. You and your mentor are free to recommend specific faculty who would make appropriate reviewers for your paper, or note faculty members whom you would prefer not to review the paper. These recommendations will be taken into consideration, but the editor will make the final decision assigning reviewers.

The information you provide serves two purposes: (1) to allow the MISE editor to identify faculty members who have the appropriate areas of expertise to provide a relevant review, and (2) to establish the context of the study and audience of the paper for the reviewers, so that they can provide a review that will improve your paper for external submission.

Your ERR paper and accompanying cover letter should be submitted to the current SCI 6170 instructor. Please allow 4-6 weeks for the review process.

The Review Process:
Two MISE faculty members plus the MISE editor will provide written reviews of your paper. Anonymity is at the discretion of the individual reviewers. At the conclusion of the review process, the two reviewers and editor will reach a consensus as to whether your paper has passed the Early Research Paper Requirement. Both you and your mentor will receive notification of the final recommendation and copies of the reviews. Two outcomes are possible:

1. A "Pass" indicates that your paper demonstrates a capacity to pursue original research and write the results in a manner suitable for submission to a peer-reviewed journal. You are encouraged to consider the reviewer and editor comments in revising your paper for external submission. No further action with the MISE internal review is required.

2. A "Revise and Resubmit" indicates that your paper does not meet these expectations. You are allowed to submit a suitably revised version of your paper only once in order to pass the paper requirement. The resubmitted paper should be accompanied by a cover letter that point-by-point addresses each of the MISE editor and reviewer concerns. You and/or your mentor may request a meeting with the MISE editor (and reviewers) to further discuss the feedback on your paper. You are encouraged to work closely with your mentor during this review process, and must obtain his/her approval prior to the resubmission. The resubmitted paper may be sent to the same faculty reviewers, or may be sent to one or more new reviewers who will be asked to check that all of the prior concerns have been addressed.

If you receive a "Revise and Resubmit" on the first attempt, two outcomes are possible on the second attempt:

1. A "Pass" indicates that the paper has been suitably revised to address the reviewer concerns, and that it now demonstrates your capacity to pursue and write up original research. No further action with the MISE internal review is required.

2. A "Not pass" indicates that your paper is insufficiently revised to address the reviewer concerns. At this point, a full review of your progress in the program will be conducted by the MISE faculty. Based on this review and on your performance during the ERR process, the MISE faculty will determine whether you will be allowed to continue in the doctoral program and on what conditions, or dismissed.

What will happen if your mentor is serving as editor at the time you submit your ERR paper
The procedure is the same, except that when you submit your paper to the current editor, he or she will direct it to the immediate past editor, who serves as a "back-up" editor. Your mentor will neither serve as editor nor as a reviewer.

13. Appendix IV. Rubric for the Review of ERR manuscripts

There are many types of research in science education, as there are in research generally. Thus research may be empirical, conceptual, theoretical, historical or philosophical, and often a combination. Papers arising from research will reflect this, and the rubric below provides a reviewing guide that should be interpreted flexibly in this light; not all aspects will apply in all cases.

Aspect for Evaluation With suggested questions to guide evaluation	Rating	Comments
1. Nature, purpose and significance of the project Is the essence and purpose of the project clearly described along with suitable background, rationale and context? Are the issues that the study addresses clearly outlined? Have the authors adequately demonstrated the originality, importance and significance of the study?	Excellent Good Fair Poor Not Applicable	
2. Relevant background and literature Is the background and literature cited clearly related and relevant to the various aspects of the project, critically appraised, and reasonably complete/comprehensive?	Excellent Good Fair Poor Not Applicable	
3. Research goals/questions Are the research goals and/or questions clearly stated and appropriate? Are the goals and questions well motivated with reference to the relevant literature?	Excellent Good Fair Poor Not Applicable	
4. Research design and methodology Are all concepts, constructs and methods clearly articulated and defined? Is the design of the study appropriate to tackle the research goals? and Are the methods, procedures, research methodology and instruments suitable, motivated, and aligned with the goals?	Excellent Good Fair Poor Not Applicable	
5. Research procedures, data and analyses Has the research been conducted appropriately? For an empirical study, was data collection careful and adequate using appropriate methods and instruments? Are the analysis methods explicit, suitable and well-motivated? Where applicable, are data analyzed correctly and interpreted appropriately?	Excellent Good Fair Poor Not Applicable	
6. Results, interpretation, argumentation and discussion of Findings Are the research results clear and well presented? Are findings and insights well argued and discussed? Are suitable examples and/or data extracts provided? Are the conclusions and/or implications appropriate, and is their relation to the research goals clear? Are implications for instruction discussed, within sections or separately?	Excellent Good Fair Poor Not Applicable	
7. Presentation, writing and readability Does the overall organization of the manuscript make sense, with an internal logic easy to follow? Is the structure and flow of the manuscript easy to navigate, under appropriate headings and subheadings? Is the manuscript well written and concise without unnecessary repetition or redundancy, and free of typos and grammatical errors? Is the manuscript written appropriately for the topic and intended audience? Are the tables and figures adequate, appropriate and well presented?	Excellent Good Fair Poor Not Applicable	
8. Appendices Where applicable, are there suitable appendices providing relevant material not in the main manuscript?	Appropriate Not Appropriate	
9. Style and formatting Does the manuscript conform to the stylistic guidelines of a proposed journal, including conventions for heading structure and references?	Excellent Good Fair Poor Not Applicable	

14. Appendix V: Recommended ERR Journals

Canadian Journal of Science, Mathematics and Technology Education
CBE Life Sciences Education
Chemistry Education Research and Practice
Cognition & Instruction
Cultural Studies of Science Education
European Journal of Science and Mathematics Education
Higher Education
International Journal of Biology Education
International Journal of Environmental & Science Education
International Journal of Science Education
International Journal of Math and Science Education
International Journal of STEM Education
International Research in Geography and Environmental Education
Journal of Astronomy and Earth Sciences Education
Journal of Biological Education
Journal of Chemical Education
Journal of Curriculum Studies
Journal of Engineering Education
Journal of Geoscience Education
Journal of Geography and Higher Education
Journal of Research in Science Teaching
Journal of Science Education and Technology
Journal of Science Teacher Education
Journal of the Learning Sciences
Physical Review Special Topics - Physics Education Research
Research in Science Education
Research in Science and Technology Education
School Science and Mathematics
Science & Education
Science Education
Science Education International
Studies in Science Education

This list is not exhaustive.

15. Appendix VI. Rubric for Review of CCLR Documents

Table 1
Literature Review Scoring Rubric

Category	Criterion	1	2	3	4
1. Coverage	A. Justified criteria for inclusion and exclusion from review.	Did not discuss the criteria inclusion or exclusion	Discussed the literature included and excluded	Justified inclusion and exclusion of literature	
2. Synthesis	B. Distinguished what has been done in the field from what needs to be done.	Did not distinguish what has and has not been done	Discussed what has and has not been done	Critically examined the state of the field	
	C. Placed the topic or problem in the broader scholarly literature	Topic not placed in broader scholarly literature	Some discussion of broader scholarly literature	Topic clearly situated in broader scholarly literature	
	D. Placed the research in the historical context of the field.	History of topic not discussed	Some mention of history of topic	Critically examined history of topic	
	E. Acquired and enhanced the subject vocabulary.	Key vocabulary not discussed	Key vocabulary defined	Discussed and resolved ambiguities in definitions	
	F. Articulated important variables and phenomena relevant to the topic.	Key variables and phenomena not discussed	Reviewed relationships among key variables and phenomena	Noted ambiguities in literature and proposed new relationships	
	G. Synthesized and gained a new perspective on the literature.	Accepted literature at face value	Some critique of literature	Offered new perspective	
3. Methodology	H. Identified the main methodologies and research techniques that have been used in the field, and their advantages and disadvantages.	Research methods not discussed	Some discussion of research methods used to produce claims	Critiqued research methods	Introduced new methods to address problems with predominant methods
	I. Related ideas and theories in the field to research methodologies.	Research methods not discussed	Some discussion of appropriateness of research methods to warrant claims	Critiqued appropriateness of research methods to warrant claims	
4. Significance	J. Rationalized the practical significance of the research problem.	Practical significance of research not discussed	Practical significance discussed	Critiqued practical significance of research	
	K. Rationalized the scholarly significance of the research problem.	Scholarly significance of research not discussed	Scholarly significance discussed	Critiqued scholarly significance of research	
5. Rhetoric	L. Was written with a coherent, clear structure that supported the review.	Poorly conceptualized, haphazard	Some coherent structure	Well developed, coherent	

Note: The column-head numbers represent scores for rating dissertation literature reviews on 3-point and 4-point scales (endnote 4 explains our choice of the two types of scales). Adapted from *Doing a Literature Review: Releasing the Social Science Research Imagination* (p. 27), by Christopher Hart, 1999, London, SAGE Publications. Copyright 1999 by SAGE Publications. Adapted with permission.

16. Appendix VII. Article Dissertation Policy (an alternative to the traditional dissertation structure)

1. **The article dissertation will be comprised of a minimum of three articles**. The articles should form a cohesive body of work that supports a theme or themes that are expressed clearly in the introduction to the dissertation (Chapter 1).

2. **A maximum of one article published or accepted for publication prior to the *proposal defense* may be included**. This article must represent work undertaken while the student is enrolled in the PhD program at WMU and be approved by the committee at the time of the student's proposal defense. This article must be connected to the theme or themes of the dissertation. If a previously published article is approved by the committee, the student will be responsible for securing necessary permissions from the copyright holder and other authors. Students must have their dissertation committee's permission to use their ERR paper to fulfill this requirement.

3. It is expected that the articles submitted for the defense are of publishable quality **as decided by the committee**. The committee's judgment on the publishability of the articles shall be the only judgment that impacts the decision to approve the student's dissertation.

4. **The student will submit at least one article to a science education journal agreed upon by the committee prior to the dissertation defense.** The committee and the student will agree on the topic of the article and the journal to which the article will be submitted. The article need not be accepted for publication prior to the student's graduation, so long as the committee determines that the article is of publishable quality

5. Articles may have been published before the defense. However; if so, the student must obtain copyright permission from the publishing journal to include the article in his/her dissertation. Doing so is required by U.S law. When asking for permission to include the article in the dissertation, students should notify the journal editor that the dissertation will be made available on-line. All doctoral dissertations will be made available online in ScholarWorks at WMU and through ProQuest.

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> (Guidelines for the Preparation of Theses, Specialist Projects, and Dissertations, Graduate School; 2016). https://wmich.edu/sites/default/files/attachments/u67/2016/2016-Guidelines.pdf

Students must secure all copyright permissions before finalizing the dissertation. Some journals might have copyright peculiarities that make it not worth the trouble to include that specific article in the dissertation. All of these issues should be considered early on in the process and be discussed in the proposal. The student should make sure that this entire process is compliant with WMU dissertation format guidelines.

6. **At least two of the articles should be based on data that are generated and analyzed by the student**. If one of the articles is conceptual in nature, or based on a synthesis of the literature, it must be connected to the theme or themes of the dissertation without overlapping heavily with the contents of other articles. A certain amount of overlap between articles is acceptable, but whether the extent of any overlap is excessive will be determined by the student's dissertation committee. Redundancy can be carefully reduced by citing one's own work. However, self-plagiarism - reusing one's own previously written work or data in a 'new' written product without letting the reader know that this material has appeared elsewhere - is prohibited.

7. **The student must be the first author on all articles**. As first author, the students is responsible for development and articulation of a concept or idea for research, development of a proposal to pursue this idea, development of a research design, conducting research and analysis, writing major portions of a manuscript, designing an intervention or assessment (if relevant), and interpreting results. Co-authors (such as committee members, other faculty, other students, or collaborators outside of WMU) must be identified at the student's proposal defense. The role of each co-author must be presented and approved by all members of the dissertation committee for each dissertation article, and any changes in co-authorship must be approved by the student's committee.

8. If journal reviewers suggest revisions to any of the submitted manuscripts prior to the dissertation defense, **your plan for addressing those suggested revisions should be shared with your dissertation committee members and approved by all of them before you enact the changes**. Changes can be made to any of the manuscripts provided that the dissertation committee members are aware of and agree to the changes being made and their rationale. Students may opt to defer changes requested by a journal to which they have submitted an article until their dissertation has been successfully defended.

9. The article dissertation must include **an abstract** that synthesizes the articles, as well as **an introduction** (Chapter 1) and **a conclusion** (Chapter 5, assuming three articles are presented in Chapters 2-4 respectively). It may also be desirable to have a separate literature review chapter, which would then be Chapter 2.

10. The **introduction should function as the cord that weaves the various manuscripts together** and describes, for the reader, their 'collective meaning' and 'combined contribution' to the field. It should include:

a. A definition or statement of the problem
b. The importance of the problem, i.e., why it is worth researching, why it matters to the field of science education.
c. The theoretical or conceptual framework(s) supporting the research.
d. An overview of the important literature that shows the main field or fields reviewed, an overview of the literature reviewed in the CCLR, and a synthesis of each area to identify knowledge gaps.
e. The research questions addressed by the student's investigations.
f. The methodology used to answer those questions.

11. The **conclusion will briefly summarize the major findings, limitations, discussion, and recommendations**. The author will also present and discuss linkages (i.e., similarities and differences) between the separate manuscripts that are included in the dissertation, striving as much as possible to present the document as representative of a coherent body of work. The conclusion chapter 'ties' everything together and helps the reader see how the various manuscripts, taken together, make a contribution to the knowledge base regarding the problem. The conclusion chapter should also present/discuss research imperatives, or knowledge gaps, not visible when each manuscript is considered individually and should articulate an agenda for future research on the issues addressed in the dissertation.

12. The **dissertation proposal for an article dissertation** must include:

a. The introductory chapter as described in item 11 (above).
b. Copies of any completed articles including the name of the journal and date of submission (or planned submission), and an indication of the status (in preparation, in review, in press, or published)
c. A written plan for any of any articles in progress, including proposed journals to which they will be submitted
d. A timeline for completion of the work.

The defense of the article dissertation proposal is expected to parallel the proposal defense for a traditional dissertation. The article dissertation alters the format, but not the content, expected in the dissertation research. The student is still expected to present the proposal at a public defense, and to submit a 5-8 page (not including references) executive summary of their proposal as with a traditional proposal defense per the MISE handbook.

13. **The final copy of the article dissertation should be formatted and bound consistent with WMU dissertation guidelines**. This includes making all text, headings, page numbers, table titles, and figure captions the same font throughout all papers included in the dissertation. Simply inserting an existing PDF of a previously published paper is not acceptable.

14. As with any other dissertation, stude**nts should be in regular communication with all committee members** to inform everyone of research progress and to obtain timely feedback.

15. **Exceptions to any of these requirements may be granted by a majority vote of the MISE faculty and Director**.