

THE EFFECTS OF FORMATIVE ASSESSMENTS ON STUDENTS ACHIEVING LEARNING
OUTCOMES IN AVALANCHE EDUCATION

by

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of the requirements for the degree

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ABSTRACT

Avalanche education teaches backcountry travelers how to reduce avalanche risk in snow-covered backcountry terrain. Given the severe consequences of avalanches, understanding the course content is imperative for safety. However, these courses are taught outdoors in the winter, and instructors are often challenged to accurately gauge student understanding and misconceptions. This study sought to understand how the use of formative assessments, such as quick checks for understanding, helped instructors adapt their teaching to better meet learning outcomes. Formative assessments were created to target key learning objectives and implemented in a treatment course and compared to a control course. Data were collected through surveys, assessments, interviews, and observations in both the control and treatment courses. Formative assessments revealed students' misconceptions and helped instructors adapt their teaching to meet learning objectives. Additionally, the use of formative assessment led to improvements in student post test scores, engagement, and participation. Formative assessments proved to be practical and effective tools for avalanche education, supporting more accurate assessment of student understanding and deeper student engagement. In the high-risk setting of avalanche education, any improvement in educational outcomes represents progress toward ensuring student safety in the backcountry.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

I teach avalanche education in Colorado. With my 10 years working in outdoor education, current employment as a high school science teacher, and my love for backcountry skiing, this work falls at the center of a Venn Diagram showing the overlap of my personal and professional passions. Avalanche education aims to teach the skills necessary for safe travel in the winter backcountry environment. Avalanches can be deadly, and the high-stakes consequences of this work make it a compelling area to improve as an educator. While I have enjoyed teaching these courses, I have struggled to understand if my students are truly understanding the content.

Avalanche education is a unique form of education essential to backcountry winter safety. Snow avalanches pose a significant threat to anyone traveling on snow outside of ski resorts. In the United States, an average of 27 people die each year due to avalanches (CAIC, 2025). Avalanche education began in the early 1950s and teaches both professionals and recreationalists how to travel safely in the backcountry. The American Avalanche Association (AAA) regulates avalanche education in the United States. While different providers teach stylistically different courses, all recreational and professional courses cover the same content (AAA, 2017). For recreational users, multiple courses are available to match their progression and knowledge needs (Figure 1). Most backcountry users take a recreational avalanche level one course (onX, 2022). Recreationalists also have the option to take a one-day avalanche rescue course and a

three to four-day level two course (AAA, 2017). Avalanche education is widely accessible in snowy states and designed to meet the needs of novice to professional backcountry travelers.

U.S. Avalanche Education Course Structure

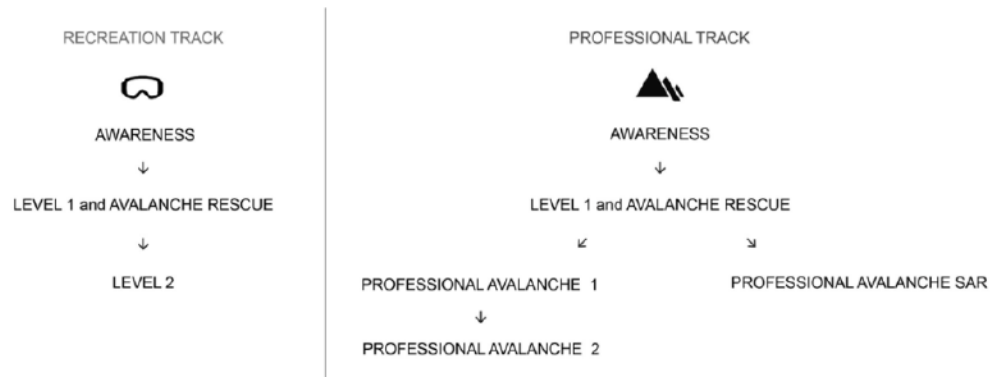


Figure 1. The American Avalanche Association's flow of educational opportunities for recreationists and professionals (AAA, 2017).

I have spent most of my avalanche education career teaching Recreational Level 1 avalanche courses. The American Institute for Avalanche Research and Education (AIARE, 2025) states that in a Level 1 course,

Students can expect to develop a good grounding in how to prepare for and carry out a backcountry trip, to understand basic decision making while in the field, and to learn rescue techniques required to find and dig up a buried person (if an avalanche occurs and someone in the party is caught) (p.1).

Before students start the course, they must complete a 12-hour online training. This training covers many of the basics of the course and provides content in various ways, including readings, videos, interactive diagrams, and tests knowledge through low-stakes quizzes. In the week leading up to the in-person class sessions, there is a 3–6-hour online session where instructors cover key topics in greater depth. The in-person course consists of two 8-hour field days. The first day involves an instructor-led tour, during which instructors cover the following

topics: (a) trailhead checks, (b) backcountry navigation, (c) avalanche rescue, (d) snow pits, (e) identifying avalanche terrain, (f) communication, and (g) safe backcountry travel. The second day is a student-led tour, where students apply concepts from both online learning and the previous day to work together to travel safely in the backcountry. Although this progression is carefully designed, it offers little opportunity for instructors to check for understanding during key moments of instruction.

The demographics of an avalanche education course vary wildly. In their study about backcountry behaviors after taking a Level 1 avalanche course, McNeil et al. (2023) found that 64.2% of AIARE Level 1 students were skiers, 20.6% were snowboarders, 3.8% were snowmobilers, and the rest were hikers, cross-country skiers, or ice climbers. Thirty-two percent of the participants were female, 64% were male, and 1.5% were non-binary (McNeil et al., 2023). The age range of participants was large, but the majority were between the ages of 25 and 44 (McNeil et al., 2023). Students' past backcountry experience varied widely, with 29% of students taking a Level 1 course in their first winter in the backcountry and 45% taking a Level 1 course within 2-5 years in the backcountry. These statistics mirror my personal experience teaching avalanche education. My classes are often mostly male students in their 20s and 30s with a wide variety of backcountry experience. The range in background knowledge and experience makes it challenging to ensure that all learners meet the learning goals, especially when teaching outdoors in the wintertime.

Throughout my time teaching avalanche education, I have struggled to assess student learning accurately. When teaching in a traditional classroom, I rely heavily on formative assessments to help me understand what my students understand and their areas of confusion.

The dynamic outdoor setting of backcountry avalanche courses, combined with time constraints due to cold weather and limited access to tools such as technology and pen/paper, all contribute to the challenge of implementing formative assessments in this setting. Additionally, the trend of adult learners to nod-along and communicate understanding even when confused contributes to an environment where I'm often unsure of what my students do and do not understand. This experience is reinforced by research conducted by Rigs Meder and Walker (2023) who noted a tendency among avalanche educators to teach along a fixed progression of topics and not adapt their teaching to students' knowledge. Despite their potential, formative assessments are not widely used or adapted in avalanche education, leaving instructors without reliable tools for adjusting instruction in the moment.

I've designed my action research (AR) project to investigate how formative assessment adapted for the avalanche education setting can help instructors better achieve learning outcomes. I created a handful of quick formative assessments that target specific learning outcomes. I collected data on student learning and instructor experience during a course taught with a traditional curriculum and with additional formative assessment use. I hope this experience will help me learn how to adapt my teaching better to meet student needs and serve as a small stepping stone for the avalanche education community to work towards better educational practices.

Focus Question

My focus question was, How do quick, technology-free formative assessments help avalanche education instructors adjust their teaching to meet learning objectives?

My sub-question is:

1. How accurately do quick, technology-free formative assessments reflect student knowledge in avalanche education?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Introduction

In recent years, avalanche education has become increasingly important due to the increased number of backcountry users and the risk associated with traveling in the backcountry (Birkland et al., 2017; Valle et al., 2022). Avalanche education, a subset of outdoor education, draws from the following learning theories: (a) constructivist, (b) experiential, (c) authentic learning, and (d) andragogy. These theories suggest that students learn best through active, experimental engagement and subsequent reflection. This is particularly appropriate for the dynamic and challenging environment of backcountry avalanche terrain. This literature review synthesizes the theoretical framework for outdoor education, reviews the current assessment practices and challenges of avalanche education, and lays the groundwork for exploring how quick, technology-free formative assessments help avalanche educators adjust their teaching to meet learning objectives.

Theoretical Framework for Outdoor Education

Constructivist Learning Theory

Constructivist learning theory underlies the conceptual framework of outdoor education. Constructivist learning theory states that students must build their understanding of topics through experience. In a constructivist classroom, teachers are facilitators and support students in actively participating in their learning (Bada & Olusegun, 2015). Allen (2022) noted that the prevalence of constructivist learning theory has led to an increase in “student-centered learning,

active learning, [and] experiential learning” (p.1). In a review of outdoor learning at higher education institutions in the United States, Townley et al. (2024) noted that most outdoor education is rooted in constructivist learning theory. However, in a review of veteran outdoor educators, Evans and Acton (2021) found that outdoor educators utilize both constructivist methods, such as reflection and group work, and behaviorist learning methods, such as instructor lectures and demonstrations. They argue that effective outdoor education incorporates both constructivist and behaviorist learning theories (Evans & Acton, 2021). While good education involves utilizing multiple techniques and learning theories, the structure of outdoor education allows a student-centered constructivist approach to be effective. Constructivist theory aligns closely with formative assessments, as both emphasize constructing knowledge through feedback and reflection.

Experiential Learning Theory and Authentic Learning

Experiential learning theory (ELT) extends the concepts of constructivist learning theory and has many principles that apply to outdoor education. Experiential learning theory emphasizes that individuals construct and understand the world through direct experiences, followed by reflection, conceptualization, and experimentation (Kolb, 1984). Morris (2020) expands on Kolb’s ideas and states that the experience needs to be novel and authentic, involve risk, and center the learner as an active participant. Dahlgren and Szczepanski (2001) apply ELT to outdoor education and note that effective use of this theory allows students to acquire skills and, through the reflection, conceptualization, and experimentation process, also develop personal growth and social competence. Inherent in the processes listed above is the need for learners to connect experiences to understanding through feedback. In this way, ELT supports the

use of formative assessments, as these give instructors the information they need to present authentic experiences, prompt reflection and support experimentation. Experiential learning theory is embedded in the structure of many outdoor education models, such as the National Outdoor Leadership School's debriefing structure and Outward Bound's facilitation practices (Hovelynck, 2021; NOLS, 2025). Experimental learning theory supports educators in helping students translate experiences into learning.

Authentic learning is a component of experiential learning theory. Herrington and Oliver's (2000) seminal paper on authentic learning argued that learners are more engaged when learning is designed around tasks and ideas related to real-world scenarios. They outline nine guidelines for authentic learning environments, including complex authentic tasks representative of real-world challenges and authentic assessments where student learning is measured by applying skills or knowledge in real-world contexts (Herrington & Oliver, 2000). Authentic learning has been broadly accepted in the educational world but has specific implications in outdoor education. Sibthorp (2003) found that the authenticity of challenges faced in outdoor education led to an increased learning about both technical skills and "valuable and transferable life skills" (p.156). However, Dassler et al. (2024) note that a challenge of authentic learning in the outdoors is the danger of learning in dynamic outdoor environments and the challenge of matching student knowledge levels to appropriate authentic situations. Authentic learning is often inherent to outdoor programs, and when it is appropriately matched to students' skills and learning needs, it can increase motivation to learn.

Connections to Andragogy

Andragogy refers to ideas about how adults learn differently from children and builds on the concepts of experiential learning theory and authenticity. Much of andragogy is based on Knowles's 1984 book *Andragogy in Action: Applying Modern Principles of Adult Learning*. Knowles outlines four different characteristics of effective adult education, noting that adult learners should be involved in planning their instruction and are most interested in topics relevant to their lives (Knowles, 1984). Additionally, Knowles asserts that adult learning should be problem-centered and that experiences should be the basis of how adults build knowledge. Here, we can see the ties between constructivist, experiential, authentic learning theory, and andragogy. Clair (2024) revisited Knowles's adult learning theory and noted concerns about the lack of empirical evidence supporting Knowles's work and his focus on Western capitalist societies, meaning the theory might not be relevant to all adult learners across different cultures. Despite critiques, Knowles's ideas are still ubiquitous in adult education and are an appropriate starting point for educators who want to understand adult education better (Clair, 2024). In a study connecting andragogy to experiential learning, O'Bannon and McFadden (2008) introduce a six-step model called the Experiential Andragogy Model. This model includes the following steps:

1. Motivation - adult learners need to be self-driven to learn.
2. Orientation – the process of introducing adult learners to self-directed learning.
3. Involvement – having adult learners participate in planning the experiences.
4. Activity – engage with real-world, authentic tasks.
5. Reflection – gaining learning through reflection.
6. Adaptation – connecting new knowledge to their previous understandings (O'Bannon & McFadden, 2008).

The authors note that outdoor experiences are the perfect place to apply this theory, as the authentic, real-world context challenges adult learners out of their comfort zone and facilitates

reflection and personal growth (O'Bannon & McFadden, 2008). The experiential andragogy model is helpful for understanding best practices when working with adults in outdoor learning settings. Formative assessments, a tool teachers can use to assess students' learning, can help elevate adult learning in experiential outdoor settings.

Formative Assessment in Outdoor and Experiential Learning

Formative assessments help teachers understand student learning. When implemented well, they can increase feedback between teacher and student (Angelo & Zakrajsek, 2024; Morris et al., 2021). A formative assessment increases a teacher's understanding of their students' progression toward their outlined learning goals. Once teachers better understand their class's progression toward learning goals, they can alter their teaching and student feedback to support each student's learning (Angelo & Zakrajsek, 2024). In a study about new trends in formative assessments in adult education, Bin (2020) found that the primary outcomes of formative assessments were increases in self-regulated learning, classroom participation, understanding, feedback, learning scores, and motivation. Formative assessments are essential tools that teachers can use to help students achieve learning outcomes. Most research has been completed on formative assessments in the classroom and for younger students; however, formative assessments are also important tools in adult outdoor education.

While there is scant literature on formative assessments in outdoor education (Casson, 2009), there is an emphasis on both verbal and written feedback in this field. Cure et al. (2018) connect formative assessments and feedback, noting that feedback is a quick form of formative assessment used in outdoor education. This is backed up by the work of Black and William (2009), who note that teachers providing feedback that moves students closer to the intended

learning outcomes is an essential element of formative assessments. Feedback is an easy tool to implement in avalanche education and can provide students with valuable learning and instructors with helpful insights (Vigane & Drystad, 2022). Additionally, other forms of quick formative assessments, such as group check-ins, pointed questions, and reflective moments can help instructors understand student learning. There is likely no literature about other traditional formative assessments in outdoor education due to the unique setting, time constraints, and lack of access to conventional classroom materials. Given this context, feedback is an essential formative tool in outdoor education, especially when teaching skills essential for safety, such as in avalanche education.

Avalanche Education

Overview and Importance of Avalanche Education

Avalanches represent a major safety concern for backcountry recreationists during the winter season. The Colorado Avalanche Information Center (n.d.), an organization that tracks avalanche-related fatalities in the United States, reports that 27 people die on average from avalanches each winter. Similarly, there are about 100 avalanche-related deaths per winter in the European Alps, most occurring outside ski resorts (Techel et al., 2016). Since the COVID-19 pandemic, there has been an increase in backcountry travelers, with skiers and snowboarders reporting spending 17% more time in the backcountry (Valle et al., 2022). Birkland et al. (2017) estimate that there have been eight times more backcountry recreators since 1995. Newer backcountry travelers have less knowledge about how to avoid avalanche hazards (Valle et al., 2022). Avalanches are deadly, and with more inexperienced people in the backcountry, the risk of

avalanche accidents is high. The increase in recreation in the backcountry has led to a need for effective avalanche education.

Avalanche education teaches backcountry travelers essential skills to increase their avalanche safety. Greene et al. (2025) used pre and post surveys to determine whether students changed their behaviors after avalanche education. They found that participants were more likely to choose less risky terrain after their education courses (Green et al., 2025). Similarly, after surveying over 1200 backcountry users, Landrø et al. (2022) found that increased avalanche education allowed backcountry travelers to assess avalanche risk factors more precisely. Evaluating risk precisely and identifying less risky terrain can help backcountry travelers avoid avalanche hazard. McNeil et al. (2023) found that students reported a higher perception of practicing essential safety skills, such as trip planning and practicing avalanche rescue, after completing a level one recreational course. Trip planning and avalanche rescue are both vital safety skills for backcountry traveling. Collectively, these studies suggest that students who participate in avalanche education learn skills that help decrease their risk when traveling in the backcountry. Despite avalanche education being an effective way to reduce risk, there are many challenges to teaching avalanche education.

Challenges of Avalanche Education

The breadth of skills needed to stay safe in avalanche terrain makes it a challenging topic to teach and learn. Safe backcountry travelers must understand the complex interplay between mountain terrain, weather, and snowpack (Dassler et al., 2024; Greene et al., 2022; Landrø et al., 2020). In addition to this, backcountry travelers must communicate observations about these factors in the backcountry and use these observations to make decisions (Greene et al., 2021;

Johnson et al., 2020). The avalanche industry has coined the term human factors to describe the challenges posed to decision-making through social dynamics and poor judgment (Johnson et al., 2020). McCammon (2004) found that human factors contributed to many avalanche-related accidents and are challenging to teach. Additionally, avalanche terrain is a “wicked learning environment” (Hogarth et al., 2015, p. 379), meaning backcountry travelers can often make poor decisions without external feedback until a catastrophic event occurs (Greene et al., 2021). The combination of these factors makes safe backcountry travel uniquely dangerous.

The immense knowledge and skill needed to travel safely in the backcountry make teaching a 24-hour avalanche level one course challenging. Many instructors find it difficult to teach all topics within the course’s timeframe (Dassler et al., 2024; Geisler & Geisler, 2016; Rigs Meder & Walker, 2023). Instructors are also challenged by the variety of student backgrounds and skills; often, there will be students who have never traveled in the backcountry in the same class as someone who has recreated in the backcountry for years (Rigs Meder & Walker, 2023). Rigs Meder and Walker (2023) assert that this variety in student backgrounds makes it challenging for instructors to understand the appropriate starting point for content and ensure all students meet the learning outcomes. Additionally, it is difficult to teach the skills of judgment, decision-making, and managing human factors as these are skills that need to be learned over long time periods (Geisler & Geisler, 2016; Johnson et al., 2022; Rigs Meder & Walker, 2023). Lastly, as the avalanche terrain is dangerous, it is hard to provide authentic learning environments due to the risk of avalanches (Dassler et al., 2024). The challenges outlined above include a lack of time and a struggle to adapt teaching to student learning. Formative assessments

are a tool that instructors could use to identify better content starting points and, therefore, effectively use the time allotted for the short avalanche courses.

Assessments in Avalanche Education

Current Practices

The field of avalanche education has identified a need to implement formative assessments that support student learning. Rigs Meder and Walker (2023) state that instructors need clear evidence that students have met the learning outcomes to create a student-centered learning process. They acknowledge a strong preference in avalanche educators to teach along a fixed progression of topics, with no adaptation regarding the student's knowledge. They advocate for considering where students are in a progression of skills and adapting lessons to fit the student's needs (Rigs Meder & Walker, 2023). Formative assessments could be an important tool to meet the expectations laid out by Rigs Meder and Walker. Geisler and Geisler (2016) note a similar theme in avalanche education and advocate using quizzes to assess learning. They assert that quizzes hold students accountable for completing the pre-course work and provide instructors with valuable feedback that can be used to adapt their learning (Geisler & Geisler, 2016). The “wicked learning environment” (Hogarth et al., 2015, p. 379) of avalanche education makes it essential that instructors give students meaningful feedback, as travelers do not receive consistent, reliable feedback from the backcountry environment (Landrø et al., 2022). Formative assessments can help instructors direct feedback on specific students' learning needs and can address this challenge of avalanche education.

Conclusion

Avalanche education relies on the foundational framework of constructivist, experiential, authentic, and andragogical learning theories. As highlighted above, the harsh learning environment of the backcountry environment, paired with the time constraints and varied student backgrounds in avalanche education, makes it essential that instructors adapt their teaching to support students in meeting learning outcomes. Formative assessments, especially those adapted to work in the dynamic outdoor environment where avalanche education takes place, could be a helpful tool to support instructors in adapting their teaching so that more students meet the intended learning outcomes.

CHAPTER THREE

METHODOLOGY

Demographics

The purpose of this study is to investigate how formative assessment adapted for the avalanche education setting can help instructors better achieve learning outcomes. My primary research question is, How do quick, technology-free formative assessments help avalanche education instructors adjust their teaching to meet learning objectives? My secondary research question is, How accurately do quick, technology-free formative assessments reflect student knowledge in avalanche education? To answer these questions, I used a mixed-methods quasi-experimental research design. This allowed me to triangulate data, connect instructor experiences with measurable student learning outcomes, and add depth and validity to my findings. This research took place in a real-world education setting where I could not randomly assign participants to groups. This made the quasi-experimental design an appropriate choice as it is often used in educational research where random assignment is not possible (Edmonds & Kennedy, 2017; Picardi & Masick, 2014; Spector, 1981). The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

This research was completed during two Level 1 AIARE classes taught in January and February 2026, ($N=24$). The first course was the control group, ($n=9$), and the second course was the treatment group, ($n=15$). Three instructors, including myself, taught each course. Both courses took place within a few weeks of each other to ensure similar environmental conditions

and a comparable winter experience for participants. These courses were taught by VNTRbirds, an avalanche education provider based in Summit County, Colorado. VNTRbird's mission is to "bring women-identifying and non-binary riders, who are comfortable in femme-centered spaces, together to build confidence and self-reliance in the outdoors through mountain biking, backcountry skiing/splitboarding, and community meet-ups" (VNTRbirds, 2025, p. 1). Ninety-six percent of the students identified as female, and 4% identified as non-binary. The ages ranged from 18 to 54, with the majority of students between 20 and 35. Sixty-six percent of students had more than one year of backcountry avalanche experience, and zero students had previously taken an AIARE course. Mertler (2025) notes that to compare groups, they must have similar demographics. Both student groups had similar experience levels and demographics, making them suitable for comparison.

Treatment

This research sought to understand how formative assessment use in avalanche education can help instructors better achieve learning outcomes. Formative assessments help teachers understand student learning and increase the feedback between teacher and students (Angelo & Zakrajsek, 2024; Morris et al., 2021). I created formative assessments to assess students' understanding of two learning objectives in an AIARE Level 1 avalanche education course (Appendix B). Of the nine learning outcomes listed by AIARE, I chose to focus on learning outcomes 4 and 5 (Figure 2).

AIARE 1 Course Learning Outcomes

By the end of an AIARE 1 course, Participants will be able to:

1. As a member of a group, apply **The AIARE Framework** to trip plan, communicate, manage risk, and reflect on the trip.
2. **Prepare** for backcountry travel each season by tracking the season's conditions and investigating trip options.
3. Contribute to the creation of a **Plan** with the support of an avalanche advisory that enables a group to limit avalanche exposure while traveling in avalanche terrain.
4. Use the **Ride Safely** checklists to monitor conditions and contribute to the process of communicating hazard and risk within a group.
5. Use the **Ride Safely** checklists to recognize avalanche terrain and use terrain that matches the conditions and skills of the group.
6. Contribute to a team that travels together, decides together, listens to every voice, challenges assumptions, and respects any veto.
7. Participate in a group **Debrief** that summarizes conditions, reviews decisions, and discusses ways to improve the plan in order to intentionally develop experience.
8. Use the **Avalanche Rescue Quick Reference** to participate with fellow group members in an avalanche rescue response.
9. Develop a plan for continuing development of skills and experience.

Figure 2. List of nine learning outcomes for AIARE Level 1 avalanche courses (AIARE, 2025).

These learning objectives state the following: (4) Use the Ride Safely checklists to monitor conditions and contribute to the process of communicating hazards and risks within a group, and (5) Use the Ride Safely Checklists to recognize avalanche terrain and use terrain that matches the conditions and skills of the group (Figure 3) (AIARE, 2025). Throughout my experience teaching avalanche courses, I have noticed that I have the hardest time checking for student learning while actively teaching in the backcountry. I chose to create formative assessments targeting learning objectives 4 and 5 because these objectives are taught and practiced while traveling in the backcountry. Each formative assessment prompted students to demonstrate knowledge of conditions, risk, avalanche terrain, and decision-making skills, and was conducted verbally through quick rating activities, discussions, and question-and-answer sessions. I hoped that these formative assessments would help increase student-to-instructor feedback and enable instructors to adapt teaching to fit student learning needs.

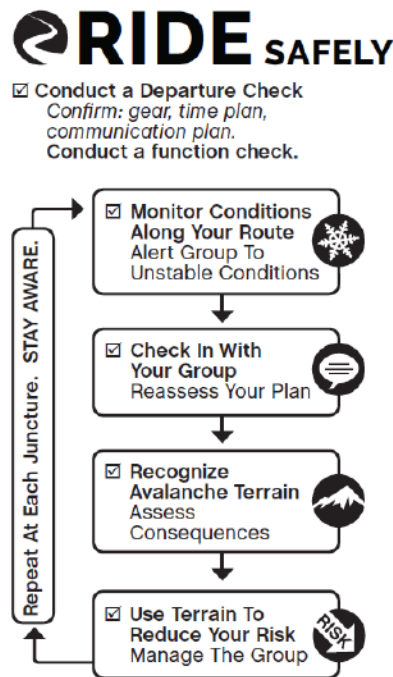


Figure 3. AIARE's ride safely checklist is a tool that students use to minimize risk while traveling in the backcountry (AIARE, 2025).

This research occurred over two avalanche education courses that took place in early Winter 2026. The first course, taught on January 3rd and 4th, was the control group, and the second course, taught on February 27th and 28th, was the treatment group. While both students and instructors were introduced to the research during the control course, no treatment was implemented. A control group is essential to my research design, given the quasi-experimental nature of my study. The setting of avalanche education made it impossible to assign groups randomly. Quasi-experimental design addresses this challenge by using a control group and a pretest/posttest data collection method, both of which help ensure that no bias occurred in group selection and highlight the differences between the groups (Edmonds & Kennedy, 2017; Picardi & Masick, 2014).

The treatment course consisted of instructors implementing multiple formative assessments to assess student learning related to learning objectives 4 and 5 (Appendix B). Instructors were introduced to the formative assessments after completing the first avalanche course (control group) to ensure that the control course reflected traditional teaching styles. Instructors were told to implement five out of the seven assessment options during the first in-person field day of the course. Beyond that, there was no standardization among instructors in the timing of assessment implementation. Teaching a field-based course is dynamic, and I wanted to give instructors the flexibility to tailor formative assessments to the group's needs, timing, and location.

I collected both qualitative and quantitative data from both the control and treatment courses (Table 1). Students in both the control and treatment courses completed a Pre and Post Test Content Assessment (Appendix C). Instructors completed a Likert Survey for both the control and treatment courses and completed a Semi-Structured Classroom Observations and a Semi-Structured Interview for the treatment course (Appendix D).

Table 1. Comparison between data collected in the control course and the treatment course.

	Control Course	Treatment Course
Student	Student Pre/Posttest Content Assessment	Student Pre/Posttest Content Assessment
Instructor	Likert Survey	Likert Survey, Semi-Structured Observations, Semi-Structured Instructor Interviews

Data Collection and Analysis Strategies

The goal of this research was to determine if quick, technology-free formative assessments helped avalanche education instructors adjust their teaching to meet learning

objectives. To answer this question, both qualitative and quantitative data were collected using multiple instruments. This data was analyzed using thematic analysis, descriptive statistics, ANCOVA, and the Wilcoxon rank sum test to understand how formative assessments helped instructors adjust their teaching and meet learning objectives.

Data Collection Methods

This research design collected both qualitative and quantitative data through multiple instruments as seen in the Data Triangulation Matrix (Table 2). Both the control and the treatment groups received a Pre and Posttest Content Assessment (Appendix C) at the beginning and end of the course. Instructors completed a Likert Survey (Appendix D) at the end of both the control and treatment courses. During the treatment course, I conducted Semi-Structured Classroom Observations (Appendix E), and all instructors completed a Semi-Structured Interview (Appendix F) at its conclusion.

Table 2. Data Triangulation Matrix.

Data Collection Instruments	Focus Questions	
	How do quick, technology-free formative assessments help avalanche education instructors adjust their teaching to meet learning objectives?	How accurately do quick, technology-free formative assessments reflect student knowledge in avalanche education?
Pre and Posttest Content Assessment	X	X
Semi-structured Classroom Observations	X	X
Semi-structured Instructor Interviews	X	
Likert Survey	X	X

Pre and Posttest Content Assessment. The goal of the Pre and Posttest Content Assessment (Appendix C) was to measure changes in student learning before and after the course. The pretest established a baseline that allowed me to compare both equivalence between groups and posttest scores (Edmonds & Kennedy, 2017; Picardi & Masick, 2014). This was important to my experimental design because I could not assign groups randomly due to the real-world setting of my experiment. Students took the in-person pretest directly before the first day of the course and the posttest directly after the last day of the course. This occurred in both the control and treatment courses. The test was designed to target students' understanding of learning outcomes 4 and 5 (Figure 2) and aligned with the learning outcomes targeted by the treatment formative assessments. The questions on the pre and post test were scenario-based because it was essential for students to understand the underlying scientific concepts that increase avalanche danger and to apply them in real-world scenarios. Additionally, I wanted to increase participation in this, so I made the pre and posttests short to minimize the likelihood of students opting out. Lastly, the pre and posttests were multiple-choice to ensure that there was minimal subjectivity in grading. This pre and posttest content assessment produced quantitative data in the form of test scores, which helped me assess the equivalence of the control and treatment groups and compare their learning outcomes.

Semi-Structured Classroom Observations. The goal of the Semi-Structured Classroom Observations (Appendix D) was to gather qualitative data to help me understand whether the information instructors collected from quick, technology-free formative assessments helped them adjust their teaching to meet learning objectives. Observational data is valuable because it extends beyond reflections participants might have expressed in an interview; it captures real-

time data about what was occurring in the field (Bailey, 2023). Additionally, observations highlighted both behaviors I wished to understand better and those I was not yet aware of, adding depth to the analysis (Burton & Bartlett, 2005). This helped me understand how instructors used the information gained from formative assessments.

I conducted Semi-Structured Classroom Observations during the treatment course to gather data and better understand how instructors utilize formative assessments. This occurred in two parts. First, I asked instructors, including myself, to audio-record the process of implementing the formative assessments, gathering information from them, and taking the next instructional steps. The reason for recording audio was twofold. First, avalanche courses took place outside in the winter, in below-freezing temperatures, making it almost impossible to take rapid, detailed observational notes. Second, this enabled me to make observations about my own process, adding depth to the collected data. I then listened to the recordings and took notes using the semi-structured outline in Appendix D. This provided qualitative data that I analyzed using thematic analysis to understand how instructors used formative assessments to meet learning objectives.

Semi-Structured Instructor Interviews. The goal of the Semi-Structured Instructor Interviews (Appendix E) was to gather qualitative data that highlighted how instructors used formative assessments to adjust their teaching to meet learning objectives. Semi-structured interviews generated rich, detailed data that helped answer research questions about how participants experienced the world (Morris, 2010; Slayton, 2018). Additionally, the prepared interview guide inherent to semi-structured interviews helped me ask open-ended and follow-up questions while ensuring the collection of data relevant to the research question (Morris, 2010;

Slayton, 2018). Using the semi-structured interview method, I gathered detailed data to examine how instructors used formative assessments and whether these assessments helped them adjust their teaching to meet learning objectives.

I used this instrument after the conclusion of the treatment course that included formative assessments. I conducted the interviews in a quiet indoor setting. Before each interview, I reviewed the interview guide (Appendix E) to ensure I was familiar with the prompts. This helped me conduct interviews that stayed on topic and allowed me to fully listen to each answer and ask relevant follow-up questions, as recommended by Slayton (2018). I audio-recorded each interview on my cell phone and dedicated time directly afterward to jot down any thoughts, notes, or impressions. I then used thematic analysis to analyze these data and gain a deeper understanding of the instructors' experiences with formative assessments. Additionally, anecdotes from these interviews added detail and depth to other forms of analysis in this study

Likert Survey. The goal of the Likert Survey (Appendix F) was to gather quantitative data to compare instructor perceptions of students' understanding of two specific learning outcomes with posttest data. This comparison helped determine whether formative assessments helped instructors accurately gauge what students knew. For this aspect of data collection, I was trying to understand the strength of agreement among instructors with statements such as "Students can effectively recognize terrain traps and explain why these features increase avalanche danger." Because Likert scales were an effective way of gathering quantitative data about "attitudes, perceptions, or behaviors," they were an appropriate choice for this instrument (Mertler, 2025, p.147). I administered this Likert survey to all instructors directly after the conclusion of both courses.

Analysis Strategies

The data collected in this research project were analyzed using both qualitative and quantitative methods.

Pre and Posttest Content Assessment. Pre and Posttest Content Assessments produced quantitative data in the form of test scores. I used descriptive statistics, including measures of central tendency and dispersion, to characterize the control and treatment groups. Then, I used ANCOVA to complete inferential statistical analysis. ANCOVA allows for the comparison of data between non-randomized groups while controlling for covariates, such as pretest scores (Keller, 2006). This makes it a particularly strong analysis for quasi-experimental pretest-posttest data, as it can account for the lack of randomization in the groups.

To complete an ANCOVA, I had to make sure my data met two criteria. First, the data had to demonstrate homogeneity of regression slopes (Knapp, 2016). The homogeneity of regression slopes ensures that the relationship between pretest and posttest scores is consistent across groups (Knapp, 2016). If this is different, then an ANCOVA is not the appropriate statistical test for the results. The second criterion that had to be met is homogeneity of variance. The homogeneity of variance is a test that measures the error across all groups. This must be similar between groups (Knapp, 2016). Both criteria were tested in Excel, and an ANCOVA was the appropriate test because there was no significant difference between groups for both tests ($p > 0.05$) (Knapp, 2016). I then ran an ANCOVA in Excel. When interpreting the results, a significant difference is observed if the p-value is less than 0.05 in the pairwise comparison (Knapp, 2016). This analysis allowed me to determine if the results from this study were statistically significant and could be applied to populations beyond the study.

Semi-Structured Classroom Observations & Semi-Structured Instructor Interviews. Both the Semi-Structured Classroom Observations and Semi-Structured Instructor Interviews produced qualitative data, which were analyzed using thematic analysis. Thematic analysis effectively highlights participants' experiences, making it a suitable method for analyzing this data (Guest et al., 2012; Peel, 2020). This analysis can help simplify complex data into meaningful themes and categories (Peel, 2020). Additionally, this form of analysis is good at identifying both explicit and implicit ideas within the data (Peel, 2020). I analyzed both sets of data by looking for themes related to how instructors used information from formative assessments to understand student learning and adjust their own teaching practices. To identify themes, I familiarized myself with the transcripts and notes. Then, I considered the question, "What specific instances of meaning exist in this text?" (Guest et al., 2012) and created a codebook that included codes that "exemplify the same theoretical or descriptive idea" (Gibbs, 2007, p. 38). This helped me move from analysis to interpretation of the data (Peel, 2020). This qualitative data was then used to add depth and nuance to the quantitative analysis through both the identification of themes and the inclusion of anecdotes and direct quotes.

Likert Survey. The Likert Survey was scored by giving each category a number (6= Strongly Agree, 1= Disagree Strongly) and produced quantitative data. The Likert Survey measured instructors' perceptions of students' understanding of the two target learning objectives. When analyzing the Likert Survey data, I calculated the median for both the control and treatment groups. I used the median because Mertler (2025) notes that the mean is not a useful descriptive statistic when analyzing Likert-scaled items because it may yield a number between the categories. I then conducted a Wilcoxon rank sum test. The Wilcoxon rank sum test

is the correct way to analyze if there is a statistical difference between the Likert Survey data because “the null hypothesis of the Wilcoxon test is usually taken as equal medians” (Ford, 2017, para. 4). This helped me understand if the instructor’s perception of student learning increased in the treatment course.

CHAPTER FOUR

DATA ANALYSIS: CLAIMS AND EVIDENCE

Formative Assessments and Instructional Adjustment

Formative assessments were effective at revealing gaps in understanding, prompting immediate instructional adjustments aligned with learning objectives. This was evident in classroom observations. One representative example of effective formative assessment occurred when an instructor used the Hazard Bingo Cards (Appendix B) to assess students' understanding of a learning objective. While reviewing the hazards students had observed so far, a student asked, "What is a convexity?" Despite this concept having been reviewed previously in online and in-person classes, no other student was able to answer this question accurately. The instructor immediately pivoted to explaining this key concept to the group. The use of this formative assessment revealed a gap in student understanding and allowed the instructor to adjust instruction to better align with the learning objectives. At the end of the explanation, students were asked to identify convexities in the field and successfully demonstrated an understanding of the important topic.

This pattern was also reflected in the interview data. One instructor referred to a similar experience using formative assessments: "I assumed because we talked about it on Thursday, and I know it was in the online learning, that they knew what trigger points were, but they didn't." The theme of formative assessments leading to identifying misconceptions was mentioned by all three instructors in interviews ($N=3$). One instructor went on to state, "It was awesome to have a consistent way of going through all of the different terrain features ... because there was

definitely at least one student who did not know what every single thing was, and then we were able to discuss it more as a group.” This quote highlights how instructors identified previously unrecognized gaps in student understanding by using formative assessment.

Formative Assessments and Learning Gains

Quick, technology-free formative assessments appear to lead to meaningful learning gains among students. Although an ANCOVA indicated no statistically significant effect of the treatment on post test scores after controlling for pre test scores ($p=0.5$), the effect size suggests a difference between the control and treatment groups that might not be detectable given the small sample size ($N=24$). The treatment group showed a large improvement from pre test to post test ($d=0.92$), whereas the control group showed a medium improvement ($d=0.54$). As shown in Figure 4, the treatment group’s post scores were both higher and less variable than those of the control group (Figure 4). The control group post test scores ranged from 3 to 8 (maximum score), with a mean of 7.33 and a standard deviation of 1.65, while the treatment group ranged from 7 to 8, with a mean of 7.93 and a standard deviation of 0.24 (Figure 4). This indicates both a more consistent, higher test performance and lower variability in post test scores for the treatment group.

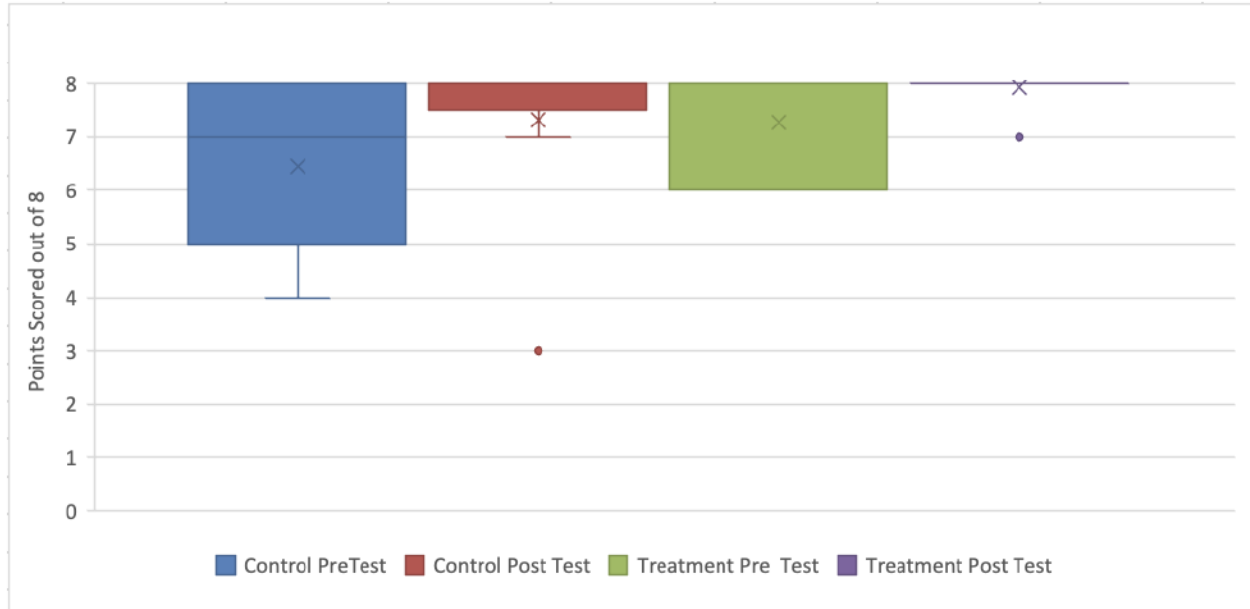


Figure 4. Content assessment scores on pre and post tests for the control ($n=9$) and treatment groups ($n=15$).

These quantitative patterns are supported by qualitative findings, which suggest that increased participation and more thorough learning may explain the higher and less variable post test scores in the treatment group. Three consistent themes emerged across the Semi-Structured Instructor Interview: (a) using formative assessments in the treatment course improved group participation, (b) made assessment of learning objectives more thorough, and (c) led to thought-provoking debriefs (Table 3). Together, these themes suggest that the use of formative assessment increases student engagement.

Table 3. Themes related to formative assessments increasing learning gains from Semi-Structured Instructor Interviews, ($N=3$).

Theme	Description	Participants (n/N)	Frequency (Count)
Improved Group Participation	Formative assessments, particularly interactive and structured activates, increased participation to a wider range of students, including those who might otherwise remain quiet. These strategies created more opportunities for students to contribute.	3/3	7
Made Assessment of Student Learning More Thorough	Structured formative assessments provided more comprehensive insight into student understanding of learning objectives. These tools helped instructors check for understanding across multiple concepts rather than relying on assumptions or surface-level checks.	3/3	9
Led to Thought-Provoking and In-depth Debriefs	Formative assessments, particularly when paired with reflection or discussion, generated deeper conversations about learning. These debriefs helped reveal student thinking, clarify reasoning, and extend understanding beyond initial responses.	3/3	8

When discussing traditional ways to assess student learning, instructors noted that it was challenging to assess the learning of quieter students ($N=3$), with one instructor saying, “With a quieter group, I often have no idea [what they understand].” This suggests that instructors might miss misconceptions among less vocal students when using more informal ways to assess student learning. In contrast, instructors appreciated that the formative assessments “gave everyone a consistent way of engaging” and noted that this allowed a more comprehensive understanding of the whole group’s misconceptions. Broader participation during formative assessments may also explain the decreased variability in post test scores observed in the treatment group, as instructors were better able to identify and address misconceptions across all students rather than only the most vocal participants (Figure 4).

All instructors noted that “the debrief from [the formative assessment] was really useful” in prompting nuanced conversations ($N=3$). This was evident in a classroom observation where a question prompted by a formative assessment led to a detailed discussion about analyzing weather conditions and their impact on avalanche hazard during multi-day backcountry trips. This anecdote highlights how formative assessment can lead to deeper learning.

Alignment of Instructor Perception and Student Performance

Formative assessment use was associated with closer alignment between instructors' perception of student understanding and student performance on the post test content assessment. Instructors completed a Likert-scale survey at the conclusion of both the control and treatment courses, in which they rated their level of agreement with statements about students' understanding of key learning outcomes. For the control course, the median instructor response was “somewhat disagree” (Figure 5). The students in the control test scored an average of 91% on the post test, indicating that a large majority answered questions about the learning objectives correctly. This shows a disconnect between instructors' perceptions and students' performance, in which instructors underestimated students' understanding despite strong post test scores. In the treatment course, the median response to the Likert Survey was “Agree” (Figure 5). The students in the treatment group had a mean post test score of 98%. This indicated a closer alignment between perceived and demonstrated learning. This result is supported by interview data, in which all instructors reported that formative assessments improved their ability to accurately gauge student understanding ($N=3$).

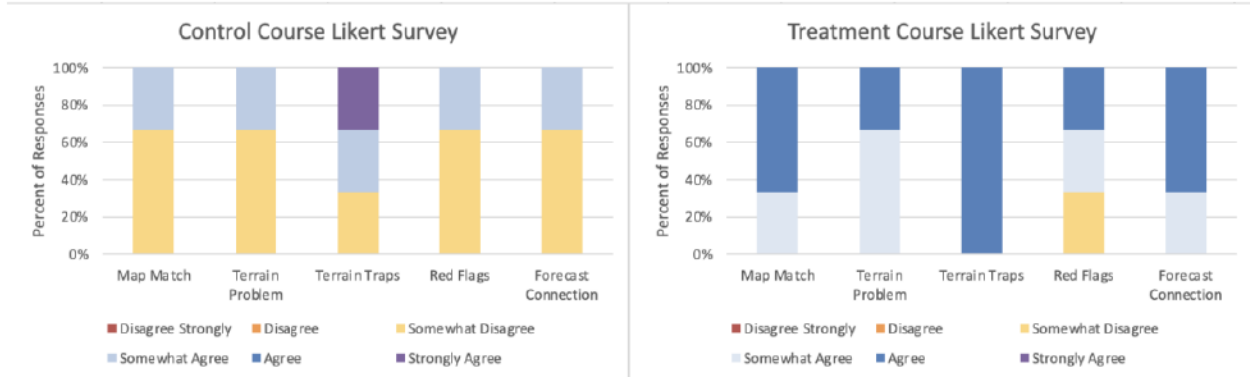


Figure 5. Comparison of instructor perceptions of student understanding across five learning objectives in control and treatment courses, based on Likert-scale survey responses, ($N = 3$).

CHAPTER FIVE

VALUE: REASONING AND REFLECTION

Claims From the StudyInstruction Support

Using formative assessments allowed instructors to adapt their teaching in real time to address students' misconceptions. All instructors ($N=3$) reported that formative assessments helped reveal student misconceptions. This highlights a well-researched aspect of formative assessments that they increase feedback between students and teachers (Angelo & Zakrajsek, 2024). In an interview, one of the instructors noted that in the control course, she felt she had "no idea" what the quieter students understood, but using the formative assessment allowed her to gather data on the whole group's understanding. This suggests that formative assessments not only increase the quantity of feedback between instructors and students but also broaden the reach of instructional practices to better include quiet students.

A surprising theme highlighted by this research was the usefulness of structured formative assessments for covering all learning objectives in the field. Instructors noted multiple times that they appreciated having a "consistent way of going through [objectives]," and two of the three instructors noted that the formative assessments felt like a helpful "checklist to steer teaching." This highlights an unforeseen impact of the formative assessments; they gave instructors a way to keep their teaching closely aligned with the AIARE learning objectives. All instructors ($N=3$) noted that a challenge of these courses is that they often feel there is not enough time to complete all required tasks. Having formative assessments may have made it

easier for instructors to prioritize activities related directly to learning objectives. These findings suggest that structured formative assessments provide logistical support for teachers, ensuring that critical learning objectives are met, which may be especially important in the high-stakes setting of avalanche education, where students need to leave courses fully understanding learning objectives.

Educational Gain

Formative assessments can lead to meaningful learning gains. While there was no statistical difference between the control and treatment group's post test score ($p=0.5$), the treatment group had a large effect size and a higher mean score and lower standard deviation than the control group. The post test may not have captured the meaningful learning that occurred during the course. In both the control and treatment courses, over one-third of the class scored perfectly on the pre test. This indicates that the pre and post tests might not have captured important learning from the course, since so many students were able to answer correctly before the course started. Qualitative data suggested that the use of formative assessments led to increased participation, revealed misconceptions among quieter students, and prompted deeper, thought-provoking discussions. This is reflected in the current literature on formative assessments, which shows that their use led to increased classroom participation, agency, motivation, and learning (Bin, 2020). Additionally, Morris et al. (2021) found that the use of formative assessment led students to think more deeply about the content. This mirrors my experience using formative assessments in an avalanche education course; the student groups were highly engaged, and we were able to discuss important nuances related to larger themes and

learning objectives. This is important in avalanche education because students need to apply fundamental ideas to complex situations to stay safe in the backcountry.

Instructor Alignment with Student Learning

Formative assessments led to greater alignment between instructors' perceptions of student understanding and students' actual understanding. Although students performed well on the post-assessment in the control course, the instructors generally thought they did not have a good understanding of the learning objectives. This mismatch can lead to inefficient use of instructional time, where instructors focus on concepts students already understand, potentially leaving gaps in critical learning. In contrast, during that treatment course, the instructor's perception of student learning matched the demonstrated learning much better. This phenomenon is well-documented in research. Angelo and Zakrajsek (2024) note that increased feedback between instructors and students from formative assessments yields greater learning insights for instructors. Additionally, the use of formative assessment can lead to a better understanding of student thinking, allowing instructors to understand both content knowledge and how students apply it (Supovitz, 2012). Aligning instructor perception and student performance is important for strong educational outcomes. When instructors have a strong understanding of students' knowledge and misconceptions, they can better utilize the limited time in avalanche courses and fully meet learning objectives.

Value of the Study and Consideration for Future Research

This study sought to understand how to make avalanche education more effective through formative assessments. In the high-stakes setting of avalanche education, identifying

misconceptions is critical because misunderstanding a concept could put students' safety at risk. Because of these consequences, any improvement in educational outcomes should be celebrated, as it indicates students are closer to fully understanding the complex set of knowledge needed to stay safe in the backcountry.

Premade formative assessments proved valuable instructional tools in the high-stakes setting of avalanche education and supported both student learning and responsive instructor adjustments. Using structured formative assessments helped instructors teach to each learning objective and thoroughly assess students' learning, both of which are especially important in the time-limited setting of an avalanche course. These tools helped reveal misconceptions, included quieter students in group conversations, and supported instructors in adjusting their teaching to address common misconceptions. As a result, students were more engaged in the learning process, contributing to group discussions and asking questions. Instructors were also able to maximize teaching time; the formative assessments helped them align teaching with learning objectives, and their increased understanding of student learning allowed them to ensure that instructional time was used to address misconceptions or deepen student learning. In a setting where students must leave with the ability to apply knowledge in potentially life-threatening situations, these findings highlight the value of formative assessments as a practical and effective strategy for improving both teaching and learning.

Completing a research project in the dynamic, outdoor setting of an avalanche education course proved to be harder than I anticipated. Multiple classroom observation recordings were lost due to wind interference while recording. Some instructors implemented only half of the required formative assessments during the treatment course, citing that issues with student gear

and skiing ability took up too much time in their day to complete the remaining assessments. Lastly, student engagement in learning is constantly impacted by how cold they are during the course. These limitations impacted both the breadth and the depth of the data collected in this study.

There are many directions future research could go. First, repeating this study with stronger recording devices, greater instructor participation, and a more rigorous pre/posttest could yield more nuanced data, adding detail on how formative assessments support instructional adjustment and student learning gains. To extend this research, it would be valuable to better understand how the use of formative assessments supports teaching decision-making in complex, real-time field settings. Geisler and Geisler (2016) note that decision-making and managing nuance are essential backcountry skills, yet challenging to teach within the short timeframe of an avalanche course. If formative assessments can help instructors teach this skill more effectively, they could better prepare students to navigate uncertainty and make thoughtful, informed decisions in the backcountry.

Impact of Action Research on the Author

In avalanche education, we implore our students to conclude every day with a debrief. The ‘wicked learning environment’ of recreating in the winter backcountry is challenging to learn in – the fickle nature of the snowpack means that we can occasionally make unsafe decisions without suffering the consequences. Sometimes it is unclear whether we made good decisions or got lucky. A debrief is a way to reflect on the day and pull essential learning that might otherwise be lost. I try my hardest to practice what I preach and debrief each day I spend in the backcountry. And here I am, at the end of a long adventure conducting research, writing

this paper, and spending time in the backcountry, taking time to debrief the experience. This step is also an essential aspect of action research; without reflection, we cannot take the next steps to continue planning and implementing ways to improve our practices. I hope the following paragraphs help illuminate some of the learning and impact this process has had on me.

At the base of action research is the belief that we grow as educators when we reflect, identify a problem, try something new, and assess how it worked. Through this process, I have felt empowered by this idea. It reminds me that teaching is an experiment; sometimes you nail it, and other times you do not. But as long as you are paying attention, collecting formal or informal data, and are willing to improve from your past experience, you are doing meaningful work. The results of this experiment were not statistically significant, and at first, I found this disappointing. However, as I analyzed the data and reflected on the process, I realized how much insight I gained. I observed moments of understanding, nuanced discussion, full participation, and engagement that numbers alone could not capture. This experience strengthened my confidence in designing and adapting lessons, reminded me of the power of reflection, and reinforced the value of taking risks in teaching. Even without dramatic shifts in test scores, I know that the process of inquiry, attentive observation, and continuous adjustment has made me a more thoughtful, responsive, and empowered educator.

Having creative, relevant, pre-made formative assessments in my figurative (and literal) back pocket made it easy to put in the extra effort to truly understand what students knew and where they were confused. In my high school science classroom, I diligently plan lessons, intentionally building in formative assessments and preparing in advance. In contrast, I often enter a full day of teaching avalanche education with only a quick bullet-point outline. Having

these pre-made assessments allowed me to increase the quality of my checks for understanding, and the resulting discussions, feedback, and nuance were well worth the prep effort. I also loved watching my adult students engage in the low-stakes competition and silliness that emerged from some of these activities (Bingo, etc.). Teaching high school students regularly, I know these strategies work to engage them, but it was especially rewarding to see adults loosen up and enjoy the same sense of play and learning. This experience sparked a renewed excitement to continue investing in creative, playful, and engaging approaches to strengthen the quality of my avalanche education teaching.

Completing this research process has given me a deeper relationship with science. Prior to this, I engaged daily with science content but had not conducted research since college. Through this research process, I have built a deeper understanding of the scientific method; I understand the value of a literature review, can explain what an effect size is, and appreciate the value of the conclusion of a paper. I feel both more capable in understanding current research through this lens and more able to explain the power and limitations of research to my science students. It has reminded me that meaningful engagement with science extends beyond content; it lives in the process of questioning, investigating, and reflecting.

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APPENDICES

APPENDIX A: MONTANA STATE UNIVERSITY'S INSTITUTIONAL
REVIEW BOARD COMPLIANCE

Your protocol was reviewed by the IRB and has been approved.

PI: Wood, Emma

Approval Date: 12/15/2025

Title: THE EFFECTS OF FORMATIVE ASSESSMENTS ON STUDENTS ACHIEVING
LEARNING OUTCOMES IN AVALANCHE EDUCATION

Protocol #: 2025-2404-EXEMPT

Review Type: Exemption

Expiration Date: 12/15/2030

Work described under this protocol may now commence. The PI is responsible for ensuring that the protocol accurately describes research practices being conducted.

- > Review Category designation determined by the IRB can be found in the final section of your protocol.
- > Any changes must be submitted via Amendment prior to implementation.
- > Per the Common Rule, research only requires Interim (annual) Review by the IRB if 1) it was reviewed via Full Committee or 2) is regulated by the FDA.
- > All research is subject to post approval monitoring.
- > All protocol types must be renewed 5 years after approval.
- > Inform the IRB once your research is complete so that the protocol may be inactivated.

Please contact your IRB Program Manager with any questions or if you are in need of assistance. Thank you for your diligence in the care of human subjects research participants.

Institutional Review Board for the Protection of Human Subjects | Office of Research
Compliance | Montana State University

APPENDIX B: FORMATIVE ASSESSMENTS

Learning Objective #4: Use the Ride Safely checklists to and contribute to the process of communicating hazards and risks within a group.

Monitor Conditions Discussion

This formative assessment will require students to pay attention to conditions over an extended period. The conversation at the end will help you understand their ability to connect observations to larger implications (ski conditions, avalanche danger, etc). This assesses their ability to monitor conditions and discuss hazards.

Give students a defined amount of time (1 hour, until the next transition, etc.) and ask them to record two written observations (or take two photos) that capture key snow or weather conditions. After the hour, students share their observations with the group (e.g., “windy on ridgelines,” “a crust layer on the surface”). Group students with similar observations. Each group discusses why their observations matter and what those conditions suggest about current or potential avalanche hazards.

Conditions → Avalanche Problems

This formative assessment assesses students’ ability to connect weather and snow observations to avalanche problems and the forecast. As this does not require students to see the conditions in person, it can be helpful on days when the conditions are less noticeable (bluebird & calm, no avalanche problems, etc.). This activity works best on a packed surface and without skis on – maybe during lunch or a transition period while digging pits.

Give students the slips (included below). Prompt students to match the condition slips to each avalanche problem. Then debrief the exercise; note what students got right, conditions that could impact multiple problem types, and points of confusion. Conclude by connecting this activity back to the part of the learning objective that states “communicating hazards and risks within a group”.

Hazard Bingo

This assesses students’ ability to monitor conditions along the route. A strength of it is that it is a simple, independent activity that highlights each individual’s ability to note conditions and discuss their importance.

Give students the hazard bingo cards (included below) at the beginning of the day and prompt them to fill them out quietly throughout the day. At each break, debrief what they have crossed off and why that is a significant observation.

Learning Objective #5: Use the Ride Safely Checklists to recognize avalanche terrain and use terrain that matches the conditions and skills of the group.

Photo Terrain ID

This formative assessment can help instructors understand students' ability to identify terrain features in the landscape. The individual nature of students' circling features will give you direct feedback on student understanding. Make sure to thoroughly debrief this as a group so that you can correct misconceptions.

Stop in an area where you can see multiple different types of terrain. Have everyone take a photo of a similar area. Using the markup function ([iPhone/Android](#)) to have each student explicitly identify terrain by circling features on their photo. Some potential options below:

- Avalanche terrain
- Terrain traps
- Low-angle slopes
- Slopes connected to avalanche terrain (underneath, run outs, nearby)
- Convexities

Have students share their photos by passing phones around and discussing the feature they circled.

Map Reading

This assesses students' ability to read a map and determine their location. While not necessarily a specific learning objective in an AIARE course, reading maps is an essential way that we manage terrain and avalanche hazard. This will help you identify students who could use additional map-reading and terrain-identification support. This activity is designed for phones, but also works if all students have paper maps.

Do this in an area with easily identifiable terrain features (open meadow, above tree line, etc.).

1. Ask students to give a thumbs-up/down rating of how comfortable they feel identifying terrain on the map in the field—note who is at the bottom of the spectrum.
2. Identify an unmistakable, easy-to-see landmark for the group (peak, gully, open slope) and ask students to drop a pin on their map for this feature.
3. As students complete this, check the accuracy of their pins, starting with the students who gave the lowest thumb rating. Use this as a 1:1 moment to correct misunderstandings. For students who gave higher confidence ratings, you can have them switch phones and determine if they all got the correct pin.

4. Conclude this activity by discussing the importance of being able to identify terrain in the field, and, if necessary, review some common map/mapping app features.

What Would Have To Change?

This formative assessment prompts students to consider the question, “What would have to change for our plan to no longer be appropriate for the group?” This targets the part of the learning objective that focuses on choosing terrain that matches current conditions and group abilities. It encourages students to think broadly across terrain, snowpack, weather, and human factors. Conduct this activity just before entering the terrain your group has discussed and agreed upon.

Have students pair up and list three or more changes that would make them uncomfortable descending the chosen slope. Encourage them to think beyond avalanche hazard—examples include surface snow deterioration, increasing winds, visibility dropping, or a group member becoming stressed or distracted. Debrief as a group and reinforce the idea that plans can and should change as conditions or group needs change.

Field Day 1 Exit Ticket

This will help you gather information about students' comfort levels with various skills and provide helpful information when planning tomorrow's tour.

Name _____

Rate your confidence with the following skills (check one box per line):

1. Monitoring snow and weather conditions throughout the day
Least Confident ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Most Confident
2. Connecting conditions to avalanche problems
Least Confident ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Most Confident
3. Identifying and communicating meaningful hazard observations to the group
Least Confident ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Most Confident
4. Identifying terrain features in the field (terrain traps, steep slopes, runouts)
Least Confident ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Most Confident
5. Reading a map or using a mapping app to understand my location
Least Confident ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Most Confident
6. Determining whether the chosen terrain matches today's conditions and group abilities
Least Confident ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Most Confident

What is one area you feel confused about or want more support with tomorrow?

Conditions → Avalanche Problem Cards

Observations: Strong winds transporting snow across ridgelines

Observations: Fresh drifts forming on leeward slopes

Observations: Cracking around skis in wind-loaded areas

Observations: Cornices growing larger after a windy night

Observations: More than 1 foot (30 cm) of new snow in 24 hours

Observations: Rapid loading from intense snowfall

Observations: Natural avalanches observed after a storm

Observations: Surface hoar present on shaded slopes

Observations: Collapsing (“whumpfing”) under skis

Observations: Shooting cracks on low-angle slopes

Observations: Weak, sugary snow near the ground

Observations: Propagating ECT (ECTP) result

Observations: Temperatures rising above freezing

Observations: Wet, sticky snow on the surface

Observations: Pinwheels forming on sunny slopes

Observations: Sluffing of loose, dry snow on steep slopes

Observations: Rain falling on snow at lower elevations

Observations: Melt-freeze crust on sun-facing slopes

Observations: Graupel layer beneath new snow

Observations: Crust layer under fresh storm snow

Storm Slab

Wind Slab

Persistent Slab

Deep Persistent Slab

Loose Dry

Loose Wet

Wet Slab

Cornice Fall

Bingo Cards:

B	I	N	G	O
Hand pit shows difference snow density/type	Cloud cover increasing	Hard snow on top of soft snow	Micro terrain hazard	Facets seen in snowpack
Terrain traps	Melt-freeze crust	Temperature change	Decreasing visibility	Rollerballs /pinwheels
Recent or current wind loading	Wet/sticky snow	Free!	Strong solar input on steep slopes	Convex rollovers
Shooting cracks	Shallow snow	Slopes > 30°	Run out from an avalanche path	Recent Avalanche Activity
Increasing wind	Surface Hoar*	Cornices	New snow accumulation	Whumpfing or collapsing

Figure 6. A bingo card to assess students' understanding of avalanche hazards and their ability to spot them in the field.

B I N G O				
Shallow snow	Shooting cracks	Facets seen in snowpack	Rollerballs /pinwheels	Terrain traps
Cloud cover increasing	Hard snow on top of soft snow	Convex rollovers	Recent Avalanche Activity	New snow accumulation
Temperature change	Micro terrain hazard	Free!	Run out from an avalanche path	Wet/sticky snow
Strong solar input on steep slopes	Melt-freeze crust	Whumpfung or collapsing	Increasing wind	Slopes > 30°
Surface Hoar*	Cornices	Hand pit shows difference snow density/type	Recent or current wind loading	Decreasing visibility

Figure 7. A bingo card to assess students' understanding of avalanche hazards and their ability to spot them in the field.

B	I	N	G	O
Wet/sticky snow	New snow accumulation	Terrain traps	Recent or current wind loading	Micro terrain hazard
Run out from an avalanche path	Temperature change	Decreasing visibility	Slopes > 30°	Hard snow on top of soft snow
Whumpfung or collapsing	Increasing wind	Free!	Cloud cover increasing	Melt-freeze crust
Shooting cracks	Recent Avalanche Activity	Facets seen in snowpack	Rollerballs /pinwheels	Cornices
Hand pit shows difference snow density/type	Shallow snow	Surface Hoar*	Strong solar input on steep slopes	Convex rollovers

Figure 8. A bingo card to assess students' understanding of avalanche hazards and their ability to spot them in the field.

B I N G O

Cornices	Whumpfung or collapsing	Terrain traps	New snow accumulation	Shooting cracks
Increasing wind	Recent or current wind loading	Hand pit shows difference snow density/type	Melt- freeze crust	Micro terrain hazard
Surface Hoar*	Cloud cover increasing	Free!	Strong solar input on steep slopes	Slopes > 30°
Convex rollovers	Shallow snow	Rollerballs /pinwheels	Facets seen in snowpack	Temperature change
Wet/sticky snow	Decreasing visibility	Recent Avalanche Activity	Run out from an avalanche path	Hard snow on top of soft snow

Figure 9. A bingo card to assess students' understanding of avalanche hazards and their ability to spot them in the field.

B I N G O				
Slopes > 30°	Wet/sticky snow	Facets seen in snowpack	Shooting cracks	Micro terrain hazard
Shallow snow	Increasing wind	Hard snow on top of soft snow	Convex rollovers	Decreasing visibility
Terrain traps	Hand pit shows difference snow density/type	Free!	Strong solar input on steep slopes	Recent Avalanche Activity
Recent or current wind loading	Temperature change	Cornices	New snow accumulation	Cloud cover increasing
Rollerballs /pinwheels	Surface Hoar*	Whumpfung or collapsing	Run out from an avalanche path	Melt- freeze crust

Figure 10. A bingo card to assess students' understanding of avalanche hazards and their ability to spot them in the field.

B I N G O				
Wet/sticky snow	Slopes > 30°	Terrain traps	Recent Avalanche Activity	Micro terrain hazard
Shooting cracks	New snow accumulation	Surface Hoar*	Melt-freeze crust	Cornices
Hard snow on top of soft snow	Temperature change	Free!	Decreasing visibility	Hand pit shows difference snow density/type
Run out from an avalanche path	Shallow snow	Recent or current wind loading	Rollerballs /pinwheels	Facets seen in snowpack
Cloud cover increasing	Convex rollovers	Whumpfung or collapsing	Strong solar input on steep slopes	Increasing wind

Figure 11. A bingo card to assess students' understanding of avalanche hazards and their ability to spot them in the field.

APPENDIX C: PRE AND POSTTEST CONTENT ASSESSMENT

Partaking in this research project is entirely voluntary, and not doing so will not impact your standing in the course or relationship with instructors.

Test Option A

1. The avalanche forecast indicates considerable hazard, noting a persistent slab on east through north aspects above tree line. You choose to ski a west-facing 28° ridge above tree line. Which statement best describes your terrain choice?
 - a. This terrain is hazardous because all steep slopes are unsafe.
 - b. This terrain avoids the forecasted problem and has a lower slope angle, which can reduce risk.
 - c. This terrain is not steep enough to produce an avalanche.
 - d. This terrain is unsafe because it is above tree line and, therefore, exposed to higher winds and more snow.
2. During your tour, you notice cracking in the snowpack around your skis and hear a “whumph” sound. What does this most likely indicate?
 - a. A stable snowpack with good bonding between layers.
 - b. Surface sun crust that is not relevant to avalanche danger.
 - c. Collapsing weak layers and potential instability in the snowpack.
 - d. A sign that temperatures are warming and the snow is melting.
3. It is the middle of the day, and you notice that the is sun warming south-facing slopes, and you see small, loose snow avalanches starting on nearby steep faces. What conclusion can you draw from this observation?

- a. Solar radiation is causing surface instability, which may increase the hazard on sun-exposed slopes.
 - b. The snowpack is stabilizing because the temperature is rising.
 - c. This information is not relevant to you because you are planning to travel and ski on west-facing terrain.
 - d. The hazard is only relevant for shaded slopes.
4. You are approaching a slope with open trees, a 35° angle, and a smooth, continuous snow surface. The slope connects to a large, steep bowl above. What factor most increases this slope's avalanche potential?
- a. The presence of trees breaks up the snowpack and stabilizes it.
 - b. The slope's connection to the larger, steeper terrain above.
 - c. The snow surface is smooth, meaning it cannot slide easily because there are no convexities.
 - d. Avalanche risk is lower because the slope is below the tree line.
5. While reviewing your route, you identify a slope that funnels into a narrow gully. What hazard does this terrain feature represent?
- a. A safe zone because snow will collect there instead of higher on the slope.
 - b. A good regrouping location with natural shelter.
 - c. A terrain trap that increases consequences if an avalanche occurs.
 - d. A low-risk slope because it's concave rather than convex.

6. The avalanche forecast lists “persistent slab problem on north-facing slopes. You dig a quick snowpit and find a weak, faceted layer 40 cm below the surface. What conclusion aligns best with your observation?
 - a. The weak layer is too deep to affect stability.
 - b. The forecast was inaccurate because the snow seemed firm at the surface.
 - c. Faceted layers usually indicate improved bonding.
 - d. Your observation confirms the presence of the problem described in the forecast.
7. Midway through your tour, your partner reports feeling uneasy after seeing a recent avalanche on a nearby slope. What is the best action according to the Ride Safely checklist?
 - a. Continue with the plan since the avalanche was not on your route.
 - b. Dig a full snowpit to collect more data before deciding.
 - c. Have only the most experienced member assess the situation to save time.
 - d. Pause to check in with your group and reassess your plan based on the new information.
8. 9. You and your group are out on a ski tour and are pleasantly surprised to find more snow than you expected from the storm last night. What observations should you and your group look for to understand how this recent storm is impacting stability?
 - a. Focus mainly on snow depth changes, since deeper snow always means it will be harder to trigger the persistent weak layer.
 - b. Look for signs of recent avalanches, or cracking that might indicate new snow may not be bonding well to old layers.

- c. Observe whether the snow surface appears smooth and uniform, as this guarantees the storm snow is well-bonded.
- d. Continue with your tour plan since a fresh storm typically improves stability by covering weak layers.

Content Assessment KEY Option A

1. B
2. C
3. A
4. B
5. C
6. D
7. D
8. B

Partaking in this research project is entirely voluntary, and not doing so will not impact your standing in the course or relationship with instructors.

Test Option B

1. The avalanche forecast reports moderate hazard with wind slabs on northwest through north through northeast aspects near and above treeline. Your group considers skiing a 32° southeast slope below treeline. Which statement best evaluates this plan?
 - a. This slope is unsafe because all slopes steeper than 30° avalanche.
 - b. This terrain avoids the listed problem aspects and elevation band, reducing risk.
 - c. This slope is completely safe because it is below treeline.
 - d. This slope is dangerous because southeast aspects can develop facets.
2. While skinning, you notice recent avalanche debris on a similar slope nearby. What does this observation most strongly suggest?
 - a. The slope already released, so nearby slopes are safer.
 - b. Avalanche activity indicates instability may still exist in similar terrain.
 - c. Debris only indicates past conditions and is not useful now.
 - d. Avalanches only occur once per storm cycle.
3. Clouds clear and strong winds begin transporting snow across ridgelines. What hazard should you anticipate?

- a. Surface hoar formation.
 - b. Rapid warming instability.
 - c. Wind slab development on leeward slopes.
 - d. Decreasing avalanche danger overall.
4. You approach a 30–33° slope that rolls over convexly and has no anchors, such as rocks or dense trees. Why might this slope be concerning?
- a. Convex slopes can increase stress in the snowpack and are common trigger points.
 - b. Slopes under 35° rarely produce avalanches.
 - c. Lack of trees always means the slope is wind-scoured and stable.
 - d. Convex slopes are safer because the snow is thinner.
5. Your route crosses beneath a large avalanche path with steep start zones above. What is the primary concern?
- a. The slope angle where you stand determines all risk.
 - b. You are safe because you are not on the steep slope itself.
 - c. Overhead hazard from avalanches starting above you.
 - d. Avalanche danger only exists during storms.
6. The forecast warns of a buried weak layer. Hand pits reveal a soft layer that collapses easily beneath a cohesive slab. What does this indicate?

- a. Stable layering because the slab is cohesive.
- b. Evidence supporting the forecasted instability problem.
- c. A harmless temperature gradient layer.
- d. A sign that stability is improving rapidly.

7. One group member says they are uncomfortable with the terrain choice but cannot fully explain why. According to the Ride Safely approach, what should the group do?

- a. Continue because no clear hazard has been identified.
- b. Stop and discuss concerns to reassess the plan together.
- c. Let the most experienced person decide alone.
- d. Ignore the concern unless a red flag appears.

8. Overnight snowfall totals are higher than forecasted. Which observation would best help your group evaluate stability changes?

- a. Whether ski tracks from yesterday are filled in.
- b. Signs of cracking, recent avalanches, or poor bonding of new snow.
- c. Whether temperatures are still below freezing.
- d. Whether visibility has improved since morning.

Content Assessment KEY Option B

1. B
2. B
3. C
4. A
5. C
6. B
7. B
8. B

APPENDIX D: SEMI-STRUCTURED CLASSROOM OBSERVATIONS

The questions below will guide the observations. Observational notes and reflections will be recorded on the document following the guide.

1. Implementation of the Formative Assessment
 - a. How does the instructor introduce the formative assessment?
 - b. Does the formative assessment fit the setting in which the instructor is using it?
 - c. Are students engaged in the formative assessment?
 - d. Are students showing an understanding or confusion about the content while completing the formative assessment?
2. Gathering and Interpreting Information from Formative Assessment
 - a. How does the instructor gather data from the formative assessment?
 - b. Does this data seem to reflect the understanding or confusion that students demonstrated while completing the formative assessment?
 - c. Does the instructor ask follow-up or probing questions to understand the student's comprehension better?
3. Instructional Response and Adaptation
 - a. Does the instructor change their teaching in response to the data gathered from the formative assessment?
 - i. If so, how?
 - b. Do students appear engaged in the follow-up to the formative assessment?

Observations	Observer Reflections

APPENDIX E: SEMI-STRUCTURED INSTRUCTOR
INTERVIEWS

Intro: Thank you so much for agreeing to participate in this interview. As I previously mentioned, this is entirely optional, and you can opt out at any time. This should take no longer than 15 minutes, and I will be recording our conversation on my phone. Is that okay?

1. Could you tell me a little bit about your experience teaching avalanche education and your experience in the educational setting?
2. Before teaching this course, how did you assess student learning and understanding?
 - a. Did you use any informal methods to check for understanding?
 - b. Did you use any formal methods to check for understanding?
3. What have been your main challenges in assessing student learning?
 - a. Can you describe a specific instance where it was difficult to tell what students understood?
 - b. Do you think these challenges are related to the subject matter, the learning environment, or the students themselves?
4. How did you use the formative assessments during the course?
 - a. Can you walk me through a specific example of when you used one of the formative assessments?
 - b. What did you notice about how students responded to the activity or question?
 - c. How did you interpret the information gathered from the assessment?
5. Can you give an example of how you adapted your teaching based on the results of the formative assessment?
 - a. What information caused you to choose to adapt your teaching?
 - b. What did you do differently?

- c. Did this change impact student engagement or understanding?
- 6. Did you feel that the formative assessments helped you gain a deeper understanding of student understanding?
 - a. Did these formative assessments help you notice any patterns in understanding or misconceptions with students?
 - b. Were there any insights you gained that you might not have had otherwise?
- 7. Were there any challenges to implementing the formative assessments or using the information gained from the formative assessments?
 - a. Logistical challenges?
 - b. Are there challenges in interpreting information gained from the assessments?
- 8. Anything else you'd like to share?

APPENDIX F: LIKERT SURVEY

Please answer the following questions based on your perception of student understanding.

1.Students can match the terrain that they have identified on the map to the terrain in the “real world”.

Strongly Agree Agree Somewhat Agree Somewhat Disagree Disagree Disagree Strongly

2.Students can accurately identify terrain features that correspond to the forecasted avalanche problems.

Strongly Agree Agree Somewhat Agree Somewhat Disagree Disagree Disagree Strongly

3.Students can effectively recognize terrain traps and explain why these features increase avalanche danger.

Strongly Agree Agree Somewhat Agree Somewhat Disagree Disagree Disagree Strongly

4.Students know what red flags to watch for during travel days and can explain how these contribute to avalanche hazard.

Strongly Agree Agree Somewhat Agree Somewhat Disagree Disagree Disagree Strongly

5.Students can connect field observations to ideas presented in the avalanche forecast.

Strongly Agree Agree Somewhat Agree Somewhat Disagree Disagree Disagree Strongly